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AN
ESSAY
ON THE
MEDICINAL PROPERTIES
OF
FACTITIOUS AIRS.

WITH AN
APPENDIX,
ON THE NATURE OF BLOOD.

BY
TIBERIUS CAVALLO, F.R.S.



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P R E F A C E.

IT is not quite forty years since the artificial aerial fluids began to be administered as remedies to the human body. The uncertainty, and the errors of the early applications, rendered the progress of the practice slow and doubtful ; nor has the experience, or the success of recent and more numerous practitioners, been sufficient to determine the precise power of the aerial fluids, or to dissipate the doubts which are still entertained concerning their use.

The desire of extricating the subject from the conflict of contrary opinions, established prejudices, and opposite interests, has induced the Author, perhaps too hastily, to publish the present work, which, in every sense of the word, deserves the epithet of imperfect. But he hopes that the importance of an object so highly interesting

teresting to the human species, may palliate, if not justify, the imperfections of the performance, which might, perhaps, have been less excusable in other subjects.

To exhibit a concise view of ascertained facts, to separate them from suppositions and hypotheses, and to point out the ways of investigating the farther use of factitious airs, has been the Author's principal aim in the compilation of the present Essay.

In the course of his inquiries, he has frequently found cause to admire the ingenuity, the caution, and the perseverance of several gentlemen, who either have administered the aerial fluids, or have otherwise exerted themselves in the promotion of their use. Yet he has taken particular care to avoid paying them any compliments, or even making frequent use of their names, lest his desire of promoting the subject should be apparently converted into an endeavour of promoting the interest of certain practitioners.

The first four chapters contain such facts as may be of theoretical use in the applications

tions of aeriform fluids, and in the investigation of their action, independent on medical cases. The fifth chapter exhibits a concise view of the modern theory of aerial fluids, and of the processes that are principally depending thereon, such as respiration, combustion, &c. The sixth and seventh chapters shew the practical application of those fluids by way of remedies to the human body; and this practice is exemplified in the eighth chapter, in which a select number of authentic cases is related. The ninth, or last chapter, contains several practical remarks, hints, &c. which could not be conveniently inserted in the preceding part of the work.

Lastly, a dissertation on the nature and properties of blood has been added by way of Appendix, that fluid being evidently and principally concerned in respiration, and in the general dependance of the animal existence on the aerial fluids.

By the mixt use of the old and the new chemical names in various parts of the work, the author imagines that his meaning
may

may be rendered less equivocal, and more generally intelligible; for at a time when the old names are not quite disused, and the new chemical nomenclature not universally understood, it is difficult to determine whether the greatest number of readers may remain satisfied with the exclusive use of either.

Wells Street,
January the 8th, 1798.

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AN
E S S A Y
ON THE
MEDICINAL PROPERTIES
OF
FACTITIOUS AIRS.

CHAPTER I.

The principal Properties of those AIRS, or permanently elastic Fluids, which have been applied as Remedies to the Human Body.

THE philosophical investigations of the two last centuries, and particularly of the present age, have ascertained the existence of various elastic fluids, analogous to common air, with respect to elasticity and invisibility; but otherwise essentially different from it, as also different from each other; such are the *dephlogisticated air*, or *vital air*, or *oxygen air*; the *phlogisticated air*, or *gas azote*; the *fixed air*, or *carbonic acid*
B gas;

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gas; the *inflammable air*, or *hydrogen gas*; the *nitrous gas*, &c. But as of all the different airs five only appear to be applicable to the human body, *viz.* the common, the oxygen, the azotic, the carbonic acid, and the hydrogen airs, we shall not therefore extend our notice to any other sort of elastic fluid; nor shall we describe more than the principal properties of those five; *viz.* such properties only as may be useful to elucidate their action on the human body.

Of the Common, or Atmospheric Air.

THAT invifible elastic fluid, which furrounds the earth, and in which we live, is indifpenfably neceffary to animal life, to combuftion, and to other proceffes. No animal can live, nor can any combuftible body burn, without air. For either purpofe the atmofpherical air is more or lefs ufeful in proportion to its purity.

WHEN common air is mixed with another particular fort of air, called *nitrous gas*, a diminution of bulk takes place, which is proportionate to the purity of the air; the

*

pureft



FACTITIOUS AIRS. 3

purest air being diminished most, and *vice versa*; so that very impure air suffers no diminution. Hence the quality or goodness of common air may be ascertained by mixing a certain quantity of it with a determinate quantity of nitrous air, and then measuring the diminution of bulk that ensues. The instrument in which this operation for ascertaining the purity of the air is made, has been called an *eudiometer*.

THE purity of common air is not the same in all places, nor is it constant in the same place at all times. The variation in the latter case is much more considerable than in the former; yet, upon the whole, it is not very great. If in the usual state of the atmosphere, and in places that are reckoned healthy, 100 parts or measures of common air be mixed with an equal quantity of nitrous air, their bulk, after the mixture, will be found, instead of 200 parts, to be between 100 and 120, more or less, according to the time of the year, situation of the place, state of the atmosphere, &c.

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But in caves, mines, crowded rooms, hospitals, work-shops, and the like, the air is less pure; yet even in this case the difference, as indicated by the test of nitrous air, is but trifling; excepting indeed those places in which the communication with the external air is absolutely or almost entirely interrupted*.

NOTWITHSTANDING the small difference which is manifested by this method of trying the purity of common air, it is however evident, from the oppression which is felt in certain instances, and the reviving effect which is experienced in other cases,

* Dr. Priestley having dined one day in company with eight or ten persons, in a large and very lofty room, and happening to go out of the room for a short time, was, on his return, struck with the offensiveness of the air, and his curiosity prompted him to ascertain the degree in which the air was injured. On trial he found that 100 parts of that air, with 100 parts of nitrous air, were reduced to 131 parts; whereas the like experiment being performed with the air of a well-ventilated room of the same house, the 200 parts of mixt aerial fluid were reduced to 125 parts.

that

that the human lungs are sensibly affected by the smallest differences in the purity of the air. But it is necessary to remark, that noxious particles are frequently suspended in common air, which do not alter the effect of nitrous gas upon it, though, at the same time, they render it very offensive to animals.

CONSIDERING the variety of vapours, minute bodies, &c. that are continually scattered through, and float in, the air, the atmosphere must be looked upon as being always contaminated by the presence of minute animal, vegetable, and even mineral, particles;—of bodies, in short, that are foreign to, or unconnected with, the nature of air.

THE quality of common air is not altered by merely heating or cooling *, or by

* Every degree of Fahrenheit's thermometer rarifies or increases the bulk of common air, by about $\frac{1}{473}$ part of the whole.

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keeping, or by being for a time loaded with the vapour of water, nor by rarefaction or condensation; but it is contaminated principally by respiration, by combustion, by the fermentation and putrefaction of animal and vegetable bodies, by the calcination of metallic substances, by the presence of vegetables when they are not under the influence of the sun's rays, and by the admixture of every other gas, or permanently elastic fluid, except the oxygen.

WHEN the common air is completely contaminated, or rendered unfit for combustion and respiration, it is (according to the present nomenclature) called *gas azote*, whereas it was formerly called *phlogisticated air*.

VITIATED air is capable of being meliorated various ways, and the methods of effecting it may be distinguished into natural and artificial. The natural means are far from being known to their full extent; but the vegetation of plants, in certain circumstances,

cumstances, and the contact of water, as in rains, dews, &c. are two very powerful correctors of contaminated air. Whether those and other natural means, are sufficient to preserve the atmospherical air nearly in the same degree of purity, or whether that degree be constantly undergoing a gradual change, so as to render the air either continually better or worse, is a very interesting question, but it can only be answered by the philosophers of future generations. For my part, I am led to suspect that the purity of the air is subject to a periodical fluctuation, or to an alternate increase and decrease for an uncertain number of years.

VENTILATION, and whatever promotes ventilation, does nothing more than remove vitiated air from those places in which it is generated, and disperse it through the atmosphere.

THE artificial methods of correcting vitiated air are few and imperfect. Ventilation, by means of bellows and other ma-

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chines, is the most efficacious, and at the same time the most practicable way of improving the air of hospitals, sick rooms, prisons, &c. *viz.* by removing the vitiated, and introducing a fresh current of purer air. A fire purifies the air of certain places, only by promoting the ventilation or circulation, and by drying the moisture; but the air which has passed through the fire must not remain in those places, otherwise the injury will be infinitely greater than the advantage. It has been confidently asserted, and denied, but it is now with limitation believed, that the vapours of nitrous, or of marine acid, will divest common air of the poisonous effluvia of contagious disorders; hence the vapours of those acids are now frequently dispersed through the air of hospitals, crowded ships, &c. When noxious vapours are merely suspended in the air, as it often takes place in several natural and artificial processes, then rest alone, or at most a slight agitation in water will be sufficient to purify the air. By the admixture of oxygen gas, a quantity of common air may be improved

proved to almost any degree ; but the method is difficult and expensive ; hence it can only be used with limitation in certain cases, which will be specified in the sequel.

Of the Dephlogisticated, or Oxygen Air.

THE oxygen is a sort of aerial fluid, that possesses the useful properties of common air in a much more eminent degree; *viz.* it assists combustion and animal respiration for a much longer time, and with superior energy. When a lighted candle is introduced into a vessel full of oxygen air, its flame becomes larger, and surprisngly brighter than in common air. Its heat is likewise increased to a very great degree.

THIS air is not found pure or unmixed in nature, but it may be extracted from various substances by means of artificial processes. The leaves of plants, indeed, yield a considerable quantity of it whilst they are exposed to the light of the sun ; but the oxygen air which is thus produced, mixes
with,

with, and is dispersed through the circum-ambient air as soon as it is generated; so that the air contiguous to the plants is seldom sensibly better than that of the neighbouring country.

By the addition of nitrous air the oxygen is diminished much more than common air. When 100 parts of good oxygen air are mixed with an equal quantity, *viz.* 100 parts, of nitrous air, their joined bulk will not exceed 50 parts, the other 150 parts having lost the aerial form. Nor is this the utmost degree of diminution that can be produced; for if 100 parts of the purest oxygen that can be procured, be mixed with twice its quantity of nitrous gas, almost the whole bulk of elastic fluid will disappear; at most, the residuum will not exceed five or six parts. By putting a lighted candle into a vessel full of any species of respirable air, and observing the effect of that air on the flame, one may estimate the degree of its purity near enough for several purposes.

THE

THE following are the principal methods of procuring this air. The green leaves of vegetables, when placed in a glass receiver full of, and inverted in spring water, and thus exposed to the direct rays of the sun, yield a considerable quantity of oxygen air, which ascends to the upper part of the receiver, and may be easily removed from it for use. One hundred leaves of Indian cress, *nasturtium Indicum*, in a gallon of spring water, will, in about three hours exposure to the sun, yield about ten cubic inches of oxygen air, not indeed quite pure, but yet vastly better than common air. I do not know of any plant whose leaves produce this sort of air in greater abundance.

THERE are several substances from which oxygen air may be extracted by the action of heat or of acids; but those which upon the whole yield it in greatest plenty, and are fit to be used, are saltpetre or nitre, and the metallic calces.

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ONE ounce of nitre, by remaining exposed to a full red, or rather a white, heat in an earthen retort for about four or five hours, will give between 700 and 800 cubic inches of oxygen air, which is not equally good in every period of the process, but at a medium it is such that if 100 parts of it be mixed with 150 parts of nitrous air, the whole will be reduced to about 100 parts. This oxygen gas contains a quantity of nitrous acid in the form of vapour, and therefore, when it is to be used for respiration, the acid vapour must be previously separated from it, which may be done by agitating the air in an alkaline lixivium, or at least in lime water.

IF an ounce of *mercurius precipitatus per se* be exposed to a barely red heat in a glass vessel, it will yield at least 66 cubic inches of very good oxygen air.

RED precipitate of mercury, when treated in the like manner, does also yield a considerable quantity of this sort of air.

THE

THE action of a red heat alone, or of vitriolic acid and a moderate degree of heat, expels from minium, or red lead, about ten or twelve times its bulk of oxygen, mixed with about one third of carbonic acid, air; the latter of which may be separated from the former by washing in lime water. If the red lead be previously moistened with nitrous acid, and then strong vitriolic acid be poured upon it, a greater quantity of oxygen gas will be obtained in a shorter time, and even without the application of heat.

THIS sort of elastic fluid may be also obtained in small quantities from several other metallic calces; but the mineral called *manganese*, gives a great quantity of it in an easy manner; it is at the same time a very cheap article, so that, upon the whole, manganese is at present the most eligible substance for the purpose of procuring oxygen air.

MANGANESE

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MANGANESE is not always of the same quality, and of course the elastic fluid, which is extracted from a given quantity of it, is variable both in quantity and quality. One ounce of good manganese, free from large calcareous particles, will, in a red heat, yield more than two pints and a half wine measure, or about eighty cubic inches of elastic fluid, about one tenth of which is carbonic acid, and the rest is oxygen gas. By means of vitriolic acid and a gentle heat, about an equal quantity of elastic fluid, nearly of the same quality, may be extracted from manganese; but in this case some acid vapours come over with it, which must be carefully washed off in order to render the oxygen air fit for respiration.

THE oxygen air is diminished to a much greater degree than common air, not only by the admixture of nitrous gas, but also by all the processes which are known to diminish atmospherical air; and indeed sometimes the whole quantity of oxygen air is absorbed or deprived of its aerial form.

form. Thus, by respiration, this air will be entirely absorbed, excepting indeed that part which is converted into fixed air.

Of Fixed Air, or the Carbonic Acid Gas.

THIS gas, which is the heaviest of the aerial fluids, is of an acid nature, but it reddens only light blue vegetable colours; it crystallizes with fixed alkali, and is possessed of a considerable antiseptic power. It is absolutely incapable of assisting respiration and combustion*; nor is it diminished by nitrous air. It combines with various substances, and is readily absorbed by water, to which it communicates an acidulous taste and sparkling property. It is also absorbed by, and precipitates the calcareous earth in lime water, but when in greater quantity, it again dissolves the cal-

* Even a mixture of one part of fixed, and eight parts of common, air will extinguish the flame of a candle. See Cavendish's paper, in the Phil. Trans. for 1766.

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careous earth in the water. It also dissolves iron in water, and keeps it dissolved therein.

THIS elastic fluid is produced in a great many natural as well as artificial processes. It is frequently found in subterranean places, especially in the vicinity of volcanos, and hot springs, where, on account of its great specific gravity, it remains for a considerable time, unless it be removed by means of ventilation, &c. It is contained more or less in almost all the mineral waters; it is abundantly produced in vinous fermentation. Respiration, combustion, and some other processes, do likewise produce a certain quantity of carbonic acid gas. It is contained in a variety of mineral substances, and particularly in calcareous earth, as chalk, marble, &c. from which substances a great quantity of that gas may be extracted by means of heat or of acids*; the calcareous

* The fixed air which is contained in white marble amounts to about one third part of its weight.

bodies remaining, after the loss of that gas, in a caustic or acrid state ; so that the calcareous earth, by being in a mild state whilst it contains that elastic fluid, may be justly considered as a neutral salt, consisting of an earthy basis and an aerial acid.

Of the Inflammable Air, or Hydrogen Gas.

INFLAMMABLE Air is the lightest of the elastic fluids. It is, as its name imports, a combustible fluid, which, like other combustible substances, may be inflamed by the contact of an ignited body, and will burn only when in contact with common, or oxygen, air.

THOUGH this sort of elastic fluid be absolutely unfit for respiration, it is not, however, so noxious as the carbonic acid. It suffers no diminution when mixed with nitrous air. Its bulk is increased of $\frac{1}{400}$ part of the whole by each degree of Fahrenheit's thermometer.

C HYDROGEN

HYDROGEN gas is abundantly produced during the dissolution of animal and vegetable bodies ; hence it is often found to come out of ponds, burying grounds, and other places that contain animal and vegetable matter in a state of decay. This gas does also frequently come out of the earth, where inflammable minerals are contained, as in coal mines, and mines of sulphureous metallic ores. But in all those cases the inflammable gas, by being much lighter than common air, ascends to the upper regions of the atmosphere as soon as it is produced, and leaves the air, adjacent to the ground, very little, if at all, infected, excepting in vaulted subterranean places, where, indeed, besides its infecting the common air, it sometimes takes fire and explodes, to the great danger of the miners.

By means of heat, or of acids, this gas may be obtained from almost all sorts of bodies, whether they be vegetable, animal, or mineral. But the greatest quantity of it may be extracted from iron, or from zinc,

by means of diluted vitriolic acid; and likewise from iron, by passing the steam of boiling water over its surface, the iron being red hot. When charcoal is treated in the last-mentioned manner, it likewise yields abundance of a peculiar sort of inflammable gas, called *hydrocarbonate*, which however is mixed with a considerable proportion of carbonic acid gas.

HYDROGEN gas has the property of dissolving and holding in suspension, for a longer or shorter time, a variety of substances, such as iron, charcoal, sulphur, phosphorus, &c. from which circumstance it acquires a variety of particular names as well as properties. Hence we hear of the *phosphoric hydrogen gas*, or *phosphuret of hydrogen*; of the *sulphuric hydrogen gas*, or *sulphuret of hydrogen*, &c.; hence also we find that the hydrogen gas is not always of the same specific gravity, nor has it always the same smell.

IT has been observed, that the hydrogen gas sometimes loses its inflammability, and degenerates into azotic air. This change happens more frequently when the hydrogen gas is mixed with common air. The cause of this phenomenon has not yet been fully ascertained.

FOR the sake both of brevity and of perspicuity I have omitted to mention the specific gravities of the abovementioned elastic fluids in the preceding pages, and shall add them all together in the following table, which contains their specific gravities as well as the absolute weight of a cubic inch of each elastic fluid.

THE gravity of common air is considerably affected by the variations of heat, wind, purity, &c. so that its specific gravity, compared with that of water, has sometimes been known to be as one to six hundred and fix, and at other times as one to nine hundred and thirty-one*. The gra-

* Musschenbroek, tom. II. §. 2059.

vities of other elastic fluids are likewise subject to the same variations. But the following table has been calculated for a mean and temperate state of the air, viz. when its gravity is to that of water, as one to eight hundred, when the height of the barometer is 29,85 inches, and when Fahrenheit's thermometer is at 55°.

<i>Names of the elastic Fluids.</i>	<i>Their specific Gravities.</i>	<i>Absolute Weight of a Cubic Inch of each in Troy Grains.</i>
Common air - - -	1 - - -	0,31648
Azotic gas, or common air completely diminished by nitrous gas - - -	0,948 - - -	0,3
Oxygen air - - -	1,0427 - - -	0,33
Carbonic acid gas - - -	1,5 - - -	0,475
The lightest hydrogen gas - - -	0,0833 - - -	0,02637

CHAPTER II.

*Facts concerning the Respiration of Common,
and of Oxygen, Air.*

THAT the whole mass of air which surrounds the earth is called the atmosphere, that this atmosphere extends to a considerable but unknown distance above the surface of the earth, that it decreases in density as it recedes from the earth, that its motion is called wind, that it acts upon all other bodies by its temperature, its weight, and other qualities, that it absorbs vapours, or keeps them suspended, and such other like properties of the atmospherical fluid, have been rendered so common by the present state of knowledge and of polite education, as not to demand any particular elucidation in this work; we shall, therefore, proceed immediately to enumerate the phenomena which have been ascertained relatively to the respiration of common air,
upon

upon which, as upon a solid basis, we may afterwards establish the theory and the practice of applying the factitious airs to the human lungs.

A CERTAIN quantity of air will support animal life, or combustion, but for a limited time. If a lighted middle-sized tallow candle be confined in a vessel that holds one gallon of common air, the flame will, in a few seconds of time, begin to grow dim, and it will be extinguished at the end of about one minute; after this, if another lighted candle be introduced into the same vessel, its flame will be extinguished immediately.

IF a man be confined in a vessel that holds ten gallons of common air, he will begin to feel an oppression, and a difficulty of respiration, at the end of eight or ten minutes; this difficulty will gradually increase, and at the end of about half an hour, reckoning from the beginning of his confinement, he will lose his sensation,

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his motion, and, presently after, his life. The same effect will take place with other animals, in a longer or shorter time, proportionably to their size, nature, and disposition of body.

In the usual way of breathing, when respiration is performed in a natural and easy manner, a full grown person consumes about five cubic feet, or thirty gallons and a half, beer measure, of common air per hour.

A MAN generally performs one inspiration and one expiration for every seven or eight pulsations of his arteries ; therefore reckoning, at a mean, eighty pulsations per minute, a person may be said to perform eleven or twelve inspirations, and as many expirations, in a minute. But respiration is quickened by various causes ; *viz.* by the quickening of the pulse, by agitation of the body, by heat, by surprise, by diseases of the lungs, by a rarefied atmosphere, and by impure air. Thus when a man is confined
in



in a certain quantity of air, his respiration is quickened in proportion as that quantity of air becomes contaminated; he also takes in and expels a greater quantity of air at a time, in order to compensate for the want of purity. The same quickening of respiration takes place on high mountains, where the air is more rare than on the level of the sea.

AT a medium, about 30 cubic inches of air are taken in at one inspiration, and a quantity, nearly equal to it, is thrown out at every expiration; but a great deal of air remains in the lungs, wind-pipe, and mouth; so that by a violent expiration after a natural inspiration, a double quantity, *viz.* sixty cubic inches of air, may be expelled, and even then some air necessarily remains in the lungs, wind-pipe, and mouth.

THE air which has served for one inspiration is not thereby completely contaminated, but it may be respired again and again. 350 cubic inches of common air
were

were confined in a bladder that was furnished with a wooden tube ; this tube was applied to the mouth of a healthy middle-aged man, who, stopping his nostrils, endeavoured to breathe that quantity of air as long as he possibly could. After having performed forty inspirations, his strength began to fail, and he was obliged to desist.

OLD persons, people of a bad habit of body, or labouring under diseases, and such as eat and drink immoderately, will contaminate the air much faster than the healthy, the moderate, and the young.

IT has been asserted, that some human beings can live with a much smaller quantity of air than has been mentioned above, and that divers have sometimes been known to remain under water ten or fifteen minutes, and even a longer time *. It has

* See Beckman's History of Inventions, article *Diving-Bell*; and Gmelin's *Reise Durch Russland*, II, p. 199.

been likewise discussed, whether such divers were enabled to remain so long under water, and without air, by any particular conformation of the internal parts of their bodies, or from long practice and particular artifices. But there are strong reasons for discrediting the above-mentioned assertions. The inaccurate way of reckoning the time in such cases, and the common fondness for the marvellous, are in general the foundation of such extraordinary reports. Upon the whole, it will be found, that the most experienced diver can hardly remain without air longer than a minute and a half; but most persons will begin to feel a degree of uneasiness in about half a minute's time.

THE air, which has been completely contaminated by respiration, is deleterious to other animals, though small and young animals will live a short time in it: it extinguishes flame, is diminished very little by nitrous air, contains about one-thirtieth of carbonic acid gas, and is contracted in
bulk,

bulk, the diminution being various, but hardly ever exceeding one-fifth part of the original quantity.

THE deleterious quality of the air that has been contaminated by respiration is in great measure owing to the carbonic acid gas, which is formed in the process of respiration; and it is for this reason that, when an animal is confined in a vessel full of respirable air, he will be able to live longer in it when some lime-water is placed in the vessel, than otherwise; because the lime-water absorbs the carbonic acid gas as soon as it is generated. An animal will likewise live longer in a vessel full of air, when he is placed at the upper than at the lower part of the vessel; because in the former case the carbonic acid gas will, on account of its great specific gravity, fall towards the lower part of the vessel, and will, of course, be at a distance from the body of the animal.

THE

THE respiration of oxygen air is attended with peculiar phenomena. The oxygen, like the common, air, is diminished by respiration; but the diminution proceeds to a much greater degree, for almost the whole quantity of elastic fluid will be reduced to a small proportion of carbonic acid gas; and if the experiment be performed on lime-water, the whole quantity of oxygen air will disappear. By repeatedly performing the experiment in this manner, it has been found that a healthy middle-aged man will entirely consume two gallons of pure oxygen air in about five minutes time*. But in this case the oxygen air is consumed faster than is necessary for the usual support of life; and, in fact, if the same quantity of it be mixed with an equal quantity of azotic

* Amongst the various ways of producing oxygen air, it frequently happens, as we have already hinted, that acid vapours, or other volatile substances, are mixed with it; and in that case the animal which is confined in it may feel an oppression on his lungs, or he may even be suffocated, when, by the test of nitrous gas, that air will actually appear to be much better than common air.

gas,

gas, it will then last as long again, *viz.* about ten minutes. It is therefore evident, that as the azotic gas is absolutely incapable of assisting respiration, the mixing of it with the oxygen air produces no other effect than that of presenting a smaller quantity of oxygen to the surface of the lungs in each inspiration. It is for the same reason that oxygen air is consumed faster, and that common air is vitiated sooner, when respired under an increased, and slower when respired under a diminished atmospherical pressure.

THE air which is expelled from the lungs after every inspiration, whether it be oxygen or atmospherical air, contains, besides the portion of carbonic acid gas, a considerable quantity of aqueous vapour, which, in cold weather, is manifested by its condensation as soon as it comes out of the mouth ; for air can hold in solution a much greater quantity of water when hot than when cold.

THE

THE breathing of pure oxygen air is generally, if not always, attended with an increase of heat, especially about the lungs, and a quickening of the pulse; but on some individuals those effects are increased to such a degree as to produce fevers, inflammation of the lungs, and even consumptions, whilst with other individuals they are moderate, temporary, and even salutary. But I shall endeavour to impress the reader's mind with a clearer idea of those phenomena, by subjoining a short account of the principal experiments that have been performed relatively to this interesting part of our subject.

Dr. PRIESTLEY is, as far as I know, the first person who had the curiosity of breathing oxygen air. “ I have,” *says he*, “ gratified that curiosity, by breathing it, “ drawing it through a glass-syphon, and “ by this means I reduced a large jar full “ of it to the standard of common air. The “ feeling of it to my lungs, was not sensibly different from that of common air, “ but

“ but I fancied that my breast felt peculiarly light and easy for some time afterwards *.”

THE following experiment was performed, with great accuracy, before a philosophical society of gentlemen, at Dr. Higin's house, in the year 1794.—Nineteen pints of pure oxygen gas were put into a receiver which stood inverted in lime-water. A tube proceeded from the upper part of the receiver to the mouth of the experimenter, a healthy man of about twenty-two years of age, who, after having accurately stopped his nostrils, and having expired as much air from his lungs as he possibly could in a bent posture of the body, took the end of the tube in his mouth, and began to breathe the oxygen air in a natural and slow manner, during which the receiver was permitted to play freely up and down in the lime-water, in order to prevent any increase or decrease of

* Experiments on Air, &c: vol. ii. p. 102.

pressure on the lungs. An assistant was employed to keep the lime-water in continual agitation, in order to promote the absorption of the carbonic acid air that was formed in the course of the experiment. The bulk of oxygen air was visibly diminished at every inspiration, and the lime-water became turbid. The whole of the oxygen air was consumed in six minutes time, and the experimenter stopped only when the lime-water came to his mouth. “ During the respiration his pulse (which, “ previous to the experiment, was only “ sixty-four) quickened to ninety beats in a “ minute, and was considerably increased “ in fulness and strength ; but he felt no “ inconvenience whatever.

“ THE vessel being immediately charged “ again with nineteen pints of gas, he re- “ spired these also, and consumed them en- “ tirely in six minutes. His pulse was in- “ creased to 120 beats in a minute, and “ was vigorous withal. He felt no in- “ convenience, but had a sense of unusual
D “ warmth

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“ warmth in his lungs. In one hour after
“ the experiment his pulse returned to
“ sixty-four *.”

DR. BEDDOES found the breathing of oxygen air extremely hurtful. “ To my own
“ lungs,” *says he*, “ it feels like ardent spi-
“ rit applied to the palate; and I have
“ often thought I could not survive the in-
“ spiration of oxygen air, as it is driven
“ from manganese by heat, many mi-
“ nutes †.”

A SINGLE inspiration of oxygen air may be kept in the lungs much longer than an inspiration of common air.

WHEN oxygen air is mixed with common air, and is then breathed in that diluted state, the lungs are less affected with

* Minutes of the Society for Philosophical Experiments and Conversations, page 146.

† Considerations on the Medicinal Use of Factitious Airs, vol. i. p. 14.

the sensation of heat, nor is the pulse quickened so much as when pure oxygen is used; yet in this diluted state the oxygen air has been found beneficial in a variety of cases, which will be mentioned in the sequel. We shall likewise mention the proportion of the two elastic fluids, which has been found to answer best for each particular case; but in the present chapter it will be necessary to state the effect which the breathing, or the action, of oxygen air has been observed to have upon particular parts of the animal body, whence proper conjectures may be formed of its general use in the animal economy, and of its application for the cure or alleviation of particular disorders.

THAT oxygen air is a powerful stimulus to the lungs, has been evinced by various experiments, but by none better than the following, which has been repeated with equal success by different persons:—Some young rabbits were kept under water till every appearance of life, and even a hope

of recovery, had vanished ; they were then withdrawn, and oxygen air was forced through the mouths of some of them into their lungs, whilst a similar operation with common air was performed on the others : the latter remained dead, whilst the former recovered. Young dogs and kittens were subjected to the like experiment, the general result of which was, that the oxygen air brought them to life where common air proved ineffectual. Animals thus apparently deprived of life have frequently revived by only being placed in a vessel full of oxygen air, without forcing it into their lungs. From this fact we derive a powerful method of restoring suspended animation.

RABBITS, dogs, kittens, and birds, have been often confined in vessels full of oxygen air, and have been suffered to remain in that quantity of air for various lengths of time. It has been constantly observed, that they live longer in that, than in an equal quantity of common air. But whenever the
experiment

experiment has been protracted to a certain length, it has almost always been attended with illness, with a strong inflammation, and even with death. The dissection of the animals that have been thus *oxygenated*, has principally exhibited the following phenomena :

THE lungs appear of a florid red colour, often marked on the edges with signs of mortification ; the heart appears of a florid red colour ; the pleura is generally inflamed ; the colour of the liver, kidneys, and the blood-vessels of the mesentery, is more inclining to red than is otherwise known to be ; their blood coagulates sooner ; their muscles are more vigorous, and shew signs of stronger irritability.

ANIMALS that have breathed oxygen air, previously to their being immersed in water, will not die so soon as those which have breathed common air only. The quantity of purer air, which remains in the lungs of the former, is what in great mea-

sure, if not entirely, contributes to the preservation of their lives.

AFTER having described, in the preceding paragraphs, the principal phænomena, which are produced by the respiration of pure, or nearly pure, oxygen air, it will be hardly necessary to add, that a mixture of common and oxygen airs, or of azotic and oxygen airs, must produce phænomena analogous to those which have been mentioned above, but nearly proportionate to the quantity of oxygen air which is contained in the mixture. There is, however, a remarkable circumstance, which must be carefully attended to, as being of the utmost consequence in the application of oxygen air to medicinal uses. This circumstance is, that whilst the respiration of pure oxygen air, or of such air as contains a great proportion of oxygen, is attended with inflammation and other bad consequences, the respiration of common air a little improved by the admixture of a moderate proportion (as for instance, one-

15th,

15th, or even one-20th) of oxygen air, is attended with remarkably salutary effects.

THE inhalation of such diluted oxygen air, or we may call it improved atmospheric air, for about 10 or 15 minutes a day, has been found to produce a florid colour in the face, to conciliate sleep, to strengthen the organs of digestion, to promote circulation, to strengthen the pulse, &c.

HOWEVER strange and unaccountable those effects may at first sight appear, especially to those who are not conversant in philosophical investigations, the facts are certainly true, and a simple reflection may contribute to dissipate the wonder; namely, that people of all descriptions, but especially such as are weak and emaciated, derive a considerable degree of exhilaration and improvement by a short excursion out of a town, or of a house, when the superior purity of the country air,

above that of the town, is not equal to that which is produced by mixing common air with even one-twentieth of its bulk of oxygen air. But we shall have occasion to notice this circumstance again in the sequel.

CHAPTER III.

Phænomena arising from breathing other aerial Fluids, besides the Common and the Oxygen Airs.

IT has already been noticed, that of the various sorts of elastic fluids, two only, *viz.* the common and the oxygen airs, are capable of assisting respiration, from which it may be naturally deduced, that by the admixture of any other gas, either of those two will be rendered less respirable in different degrees. But this diminished goodness of the respirable airs, this mixture of
respirable

respirable and unrespirable aerial fluids, has proved beneficial in a variety of medical cases ; hence many experiments have been made for the purpose of ascertaining the mixtures that are more applicable to any particular case, and likewise the phænomena which arise from the respiration of those mixed gasses.

I would not be understood to assert or think that the action of the unrespirable gasses consists merely in lowering the quality of common air, or of oxygen air ; for that purpose could be more commodiously answered by breathing a certain quantity of common air longer than in the usual way. The fact is, that, besides rendering the common or oxygen air less respirable, each particular gas imparts peculiar and remarkable properties to the mixture, which mixtures are of course applicable to particular cases. With respect to those mixtures, much has already been ascertained ; but a great deal more remains to be examined and tried under a variety of circumstances, to
which

which object we must look forward with anxious expectation.

IT has been repeatedly asserted and denied, that pure and unmixed hydrogen, or inflammable gas, may be respired with impunity for a considerable time, and many experiments are related to prove each of those contradictory assertions. The equivocal results of those experiments arise from two causes, *viz.* from the variable nature of the gas, and from the different quantity of common air, which remains in the lungs, mouth, &c. of the animals that are subjected to such experiments.

INFLAMMABLE gas, in the common way of producing it, is seldom very pure; but even when that is the case, its coming into contact with the lungs is naturally prevented by the common air, which remains in that organ previously to the application of the inflammable gas, the latter being much lighter than the former. By a strong expiration in a bent posture of the body, the
common

common air may, in great measure, be expelled ; but even in that case a certain quantity of it unavoidably remains in the mouth, wind-pipe, &c.

OF the different sorts of inflammable gas, that which is obtained by passing the steam of water over red hot iron seems to be the least offensive. Next to this is the gas which is obtained from iron and diluted vitriolic acid. The other species are more variable in their quality ; but they are all incapable of assisting respiration ; and if a person will carefully expel as much air from his lungs as he possibly can by a forced expiration in a bent posture, and will then apply his mouth to a vessel, or to a tube that communicates with a vessel, full of pure inflammable gas, keeping his nostrils stopped at the same time, he will find, after about three or four inspirations, that the florid colour of his face is vanished, and his strength is so far diminished as to prevent the prosecution of the experiment. Having myself been more than once witness

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ness to this experiment, I have always observed an evident change of colour in the face of the experimenter after the second inspiration.—The gas had been extracted from iron and diluted vitriolic acid.

INFLAMMABLE gas may be rendered less noxious by agitation in water.

WHEN this gas (meaning that which is obtained from the vapour of water and red hot iron, or from iron and diluted vitriolic acid) is mixed with about an equal quantity, or even a smaller proportion of common air, it may then be breathed with safety for a considerable time; and it is remarkable, that the lungs are affected by it with a peculiar sensation of levity. This singular property has rendered it useful and beneficial in inflammations of the lungs, convulsive coughs, &c. where the object is to diminish the irritability of the parts affected. During this operation the face will be found to grow dark or livid, but the natural colour will be speedily recovered by

afterwards breathing the common air in the usual way.

THE hydrocarbonate, *viz.* that species of inflammable gas which is produced by passing the steam of water over the surface of red hot charcoal, is much more pernicious to the lungs. Animals will die much sooner in this than in the above-mentioned species of inflammable gas. Sometimes two or three inspirations of pure hydrocarbonate are sufficient to occasion the death of the animal.

THE active quality of this gas is perceivable even when diluted with 20 or 30 times its own bulk of common air. A person who breathes it in that diluted state for about a quarter of an hour, is generally made sick and vertiginous; feeling at the same time a sensation of cold throughout his whole body; his lips become blue, the face livid, and the pulse feeble, though frequent; but the sensibility of the lungs is considerably diminished by it, on which
account

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account it has been administered in various cases with advantage to the patient. Some patients, after the respiration of this diluted gas, have experienced such levity or insensibility about the region of the lungs, as to remain for a time entirely free from pain.

It is remarkable, that the sickness, dizziness, or, in short, the bad effects of the diluted hydrocarbonate, frequently come on after the operation, and sometimes come on and go off two or three times repeatedly, at the interval of an hour or longer; which shews that this sort of gas can hardly be administered with too much care and caution.

PURE carbonic acid gas is likewise very pernicious to the lungs. Sometimes one or two inspirations of it have been quite sufficient to kill an animal; and, indeed, animals will die in carbonic acid gas, and likewise in hydrocarbonate, much sooner than if they did not respire at all, or if they
were

were immersed in water, which proves that some noxious principle is introduced by those gasses into the body.

OF the animals, those which have large lungs in proportion to their bulk, and are formed to live in the air, are sooner affected by this gas; thus the birds have in general been found to die soonest in carbonic acid air; the dogs come next, then the cats, then the amphibious animals, and lastly, the insects*. If they are not left too long in this gas, they will, in general, revive, by being removed into the common air. When they die in it they shew no struggles. By being frequently exposed to this gas, the animals may be so habituated as not to be killed by it so soon as others that were never exposed to it.

THE following are the appearances which have been more commonly observed on the dissected bodies of the animals that have been killed by carbonic acid gas.—The lungs are a little collapsed, shewing a few

* Bergman *de Acido Aereo*, sect. 26.

inflamed

inflamed places. The right ventricle and right auricle of the heart, the pulmonary artery, the *vena cava*, the jugulars, and the vessels of the brain, are turgid with blood; but the pulmonary veins, the *aorta*, the left ventricle, and left auricle of the heart, are mostly flaccid. The muscular fibres of the body are found deprived of irritability, so that even the heart, extracted whilst the body is still warm, shews no signs of irritability *.

FISHES die in a few minutes time, in water impregnated with carbonic acid gas †.

WHEN this gas is diluted with twice or three times its own bulk of common air, it may then be breathed for a certain time, but not nearly so long as the mild sorts of inflammable air similarly diluted.

PURE azotic gas is about as deleterious as the inflammable gas from iron and di-

* Bergman *de Acido Aereo*, sect. 26.

† Priestley's Exp. and Observ. vol. ii. sect. 13.
Nº 3.

luted vitriolic acid; yet the animals that are confined in it until they appear to be dead, will, on being withdrawn, recover more frequently than those which are confined in the inflammable gas.

THE artificial gasses have likewise been breathed in combinations of three or four at a time, one of them always being either the common or the oxygen air; but it does not appear that those triple or quadruple mixtures have been tried in a great variety of cases.

IN the respiring of combined gasses, due regard must be had to their specific gravities, as this circumstance is often the cause of phænomena that are erroneously attributed to other sources. The difference between the specific gravities of the common, the oxygen, and the azotic, airs, is indeed trifling; but the inflammable and the carbonic acid gasses differ considerably from the rest, and especially from each other; the former being a great deal
E lighter,

lighter, and the latter much heavier, than common air. If the inflammable, the carbonic acid, and the common or the oxygen, airs, be not well mixed together in a vessel, they will remain separate for a considerable time in their respective places, *viz.* the carbonic acid air in the lowest part, the common in the middle, and the inflammable in the highest part of the vessel; but even when they are well mixed together, they always shew a tendency to separate, so that after a short interval each of them will be found less mixed in its respective place.

It is hardly necessary to add, that the same peculiarity of situation must also take place within the lungs, and that this is, perhaps, the sole cause which renders the carbonic acid gas more noxious than the inflammable gas, and the heavy sort of inflammable gas, *hydrocarbonate*, more offensive than the lighter species of it.

CHAPTER IV.

Phænomena arising from the Application of the abovementioned elastic Fluids to other Parts of the Animal Body besides the Lungs.

IT has been found that the pores of the skin imbibe and expel a small quantity of air, and it is said, that in equal times they will absorb a much greater quantity of oxygen, than of common, or of any other, air.

DIFFERENT sorts of elastic fluid were separately injected into the cellular membrane of animals, through incisions made in the skin, and the apertures were closed immediately after. The appearances, as observed by Dr. Maxwell *, and confirmed by others, were in general as follows:

* See his Thesis, Edinburgh, 1787.

COMMON air swelled or puffed the animal, rendered it uneasy for a day or two, after which the swelling began to decrease, and vanished entirely at the end of about three weeks.

OXYGEN air swelled the animal, and rendered it somewhat uneasy for a short time; the uneasiness, however, soon vanished, the animal became unusually lively, and the swelling disappeared much sooner than in the case where common air had been used.

AZOTIC gas swelled the animal, and rendered it dull, by superinducing a sort of stupor, which, in a few days time, degenerated into convulsions, and at last killed the animal.

CARBONIC acid gas was rapidly absorbed, and seldom produced any slight and temporary uneasiness.

HYDROGEN gas swelled the animal, produced heaviness and shiverings; but the swelling

swelling disappeared sooner than in the case of common air.

MR. GIRTANTER is said to have injected azotic gas into the jugular vein of a dog, in consequence of which the animal died at the end of twenty seconds. On opening its thorax, the pericardium, and the heart, the right auricle and right ventricle were filled with black blood; the left ventricle was of its ordinary dark colour; the heart and muscles had lost their irritability almost entirely. A similar experiment being made with carbonic acid gas, instead of azotic gas, nearly the same phænomena took place.

BLOOD recently taken from the veins of an animal, and exposed to the common air, becomes of a bright red colour; and if exposed to oxygen air, its colour will become still brighter, and the oxygen air will be diminished, and partly converted into carbonic acid air. On the contrary, if the blood thus brightened, or the blood taken from the arteries of an animal, which is well

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known to be of a florid red, be exposed to any of the unrespirable gasses, its colour will be darkened presently, and a small part of the elastic fluid will be absorbed. It is to be remarked, that those effects take place even when an animal membrane, as a piece of bladder, intervenes between the blood and the respirable or unrespirable elastic fluids *. Even the colour of the fleshy parts is made to incline more towards a florid red by the action of oxygen air.

That the oxygen air acts as a stimulus on other parts of the body, as well as on the lungs, is clearly proved by the following often repeated experiment : A blister being formed on the hand, or a finger, by the application of the usual plaister of cantharides, the skin was cut off, and the hand was immediately introduced into a vessel full of oxygen air : the consequence was, that the experimenter felt a very acute pain. The hand was then removed into a vessel full of

* Priestley's Exp. and Obs. vol. III. sect. 5.



carbonic acid gas, the action of which removed the pain in a very short time. On the hand being exposed to the common air, a degree of pain returned, and on being, as at first, placed in oxygen air, the pain became acute.

THE contact of inflammable gas does neither accelerate nor retard the putrefaction of animal matter.

WHEN the stream of carbonic acid air is issuing out of a small aperture, as that of the tube of the phial in which this gas is usually produced from calcareous earth and diluted vitriolic acid, if the mouth or nostrils be presented to it, they will be affected with a peculiar, and rather pleasing, pungency.

THIS gas is possessed of considerable antiseptic power. And for this property, it is administered to the animal body either internally or externally, and separate parts of animal or vegetable substances may be preserved in it for a considerable time.

IT is applied internally to the stomach, or externally, either in the aerial form, or combined with water and other substances. Many fluid or solid bodies derive their antiseptic property from their containing this gas in considerable quantity; such are liquors in a state of vinous fermentation, ripe fruit, certain mineral waters, &c.

FRUIT may be preserved several days longer in carbonic acid than in common air. This is also the case with animal fluids, or with pieces of meat that are not very large, but they are apt to loose their flavour. Large pieces of meat are said to have been preserved for several days longer than in the usual way, by only washing them three or four times a day in water strongly impregnated with carbonic acid air.

DISTILLED water, or water that has been deprived of its air by boiling, will, in forty days time, and in a temperate atmosphere, absorb, without needing any agitation,

tion, about $\frac{1}{14}$ th of its bulk of oxygen air, whereas of common air it will absorb about the half of that quantity, *viz.* $\frac{1}{28}$ th part. It will absorb in a few hours time a quantity of carbonic acid gas little greater than its own bulk; but a cold temperature and an increased atmospherical pressure will enable it to absorb a much greater quantity of that gas. Of inflammable gas it will absorb about as much as it does of common air, *viz.* $\frac{1}{14}$ th part of its bulk.

THIS absorption of elastic fluids by water is much expedited by agitation of the latter in the former.

CHAPTER V.

Theory of the Nature of Aerial Fluids, and of Respiration.

THAT respiration and life can not be maintained without atmospherical air, is a fact known to the philosophers of the remotest antiquity ; but their ideas of the use of air in respiration were vague, and unsupported by experiments. On the revival of learning in Europe, and especially after the sixteenth century, the scientific inquiries of philosophers, physicians, and chemists, ascertained that the air was subservient to other natural as well as artificial processes, besides respiration ; and likewise that there actually existed various species of air, some of which were highly noxious *. The progress and dissemination of science gradually added new articles to

* See the works of Van Helmont and Dr. Mayow.

the stock of knowledge relative to the aerial fluids; but the great improvements, the surprising discoveries, which have produced a total revolution in this branch of natural philosophy, were reserved for the present age, and are undoubtedly due to the labours of modern philosophers.

IT is entertaining to peruse the works of authors previous to the late discoveries, and to observe how near the ideas of some of them approached the modern theory of respiration. Hippocrates considered air as one of the aliments of the body. Dr. Mayow asserts, that some nitre, or aerial spirit of nitre, enters the body through the lungs, and furnishes the animal spirits at the same time that it communicates heat to the blood*.

DR. WHITE supposed that the stimulating quality of the air is necessary to keep the heart in motion. Mr. Hewson, observ-

* See his work, printed at Oxford in the year 1674, under the title of *Traëtatus quinque Medico-Physici*.

ing that the blood has a more florid red appearance in the left, than in the right, auricle of the heart, concludes with saying, that as the change of colour in blood out of the body is occasioned by the contact of air, so it may be presumed that the same change within the body is occasioned by air also, and that the change takes place in the lungs.

DR. PRIESTLEY formed a very ingenious hypothesis concerning the use of air in respiration, which he established by a train of well-conducted experiments on the then prevailing phlogistic theory. The principal law of this hypothesis is, that the air serves to absorb the superfluous phlogiston from the blood through the lungs, and that the more or less florid redness of the blood depends on the different quantities of phlogiston in it *. The phlogiston, however, or principle of inflammability, is not

* For a full explanation of this hypothesis see the Doctor's Exper. and Obs. vol. III. sect. 5 ; or the Phil. Transf. vol. LXVI. ; and likewise Dr. Crawford's work on Animal Heat and Inflammation.

a real, but a supposed, agent in nature, which, for want of better information, was applied to explain most of the phænomena of combustion, decomposition, and (by Dr. Priestley's ingenuity) of respiration. But the present state of knowledge being, in consequence of very recent discoveries, sufficient to account for the abovementioned phænomena in a simpler, and, of course, a more natural way, the supposition of the phlogistic principle is become altogether superfluous.

OF this new or antiphlogistic theory, which may be seen at large in a variety of recent publications, and of the discoveries which gave rise to it, I shall briefly mention such particulars only, as may be of use in elucidating the action of the aerial fluids on the human body. As for the facts upon which its several parts are established, and likewise for the objections which have been made to it, I must refer the reader to the works of other authors *.

* See Lavoisier's Elements of Chemistry, Dr. Priestley's pamphlet, entitled, Experiments and Observations relating to the Analysis of Atmospheric Air, &c.; Fourcroy's Chemistry, &c.

THIS

THIS theory is at present almost universally adopted by persons of the first rank in philosophy, and daily experience is continually throwing new light upon it; yet it must be confessed that it is by no means free from doubts and difficulties. It is in consequence of those deficiencies, and on account of the uncertainty, which is inseparable from the nature of hypotheses, that I have carefully separated the knowledge of facts from the supposition of their causes. The former have been arranged in the preceding four chapters, and any person may account for them in the manner he likes best; but it was deemed necessary, at the same time, to add the most satisfactory explanation which can be suggested by the present state of knowledge, and this explanation will be found in the present chapter.

THE sensation of heat is supposed to be produced by a peculiar fluid called *the caloric*, or elementary heat; a fluid extremely fine, penetrating, and so light that its weight cannot



not be estimated. All sorts of bodies are expanded by the addition, and contracted by the abstraction of caloric. The accession of it to the human body produces the sensation of heat, and the separation of it produces the sensation of cold. Thus when we touch a substance which is of a lower temperature, viz. colder than our bodies, that substance, by robbing us of a portion of caloric, will excite the sensation of cold; and on the contrary, if the substance be hotter than our bodies, it will excite the sensation of heat, by adding caloric to our bodies.

WHEN a number of bodies of different temperatures are put together, the sum of their quantities of caloric will be dispersed amongst them in such a manner as to render them all of the same temperature, so that a thermometer will be found to indicate the same precise degree of heat in any one of them. But it must be remarked, that though the temperature be the same, yet the abovementioned sum of elementary heat will not be divided equally amongst the
bodies,

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bodies, unless the bodies be of the same fort, as, for instance, three or four parcels of water, or of mercury, &c.; but some bodies will imbibe more and others less of the caloric, in order to be raised to the same temperature, or apparent degree of heat; and this peculiar disposition in any particular body is called its *capacity for containing* caloric. This property of bodies may be rendered more intelligible by an example or two. Suppose that a pint of water, at 100° of heat, be mixed with another pint of water at 200° of heat, the heat of the mixture will be nearly 150° , *viz.* an arithmetical mean between the two temperatures; but if a pint of water at 100° of heat be mixed with a pint of quicksilver at 50° of heat, the heat of the mixture will be found to be 80° , (*viz.* greater than 75° , which is the arithmetical mean) which shews that either the quicksilver or the water, has imbibed more than its equal share of caloric, in order to have its temperature raised to the common degree of sensible heat. On the other hand, if the degrees of heat be reversed,

reversed, *viz.* the water at 50° be mixed with an equal bulk of quicksilver at 100° , the temperature of the mixture will be 70° , which plainly shews, that water absorbs more heat than quicksilver; and as the difference between their original temperatures and the temperatures of the mixture in the first and last case is as two to three, we therefore say, that the absolute heat of mercury is to that of an equal bulk of water as two to three; *viz.* “that the comparative quantities of their *absolute* heats “are reciprocally proportionable to the “changes which are produced in their “*sensible* heats, when they are mixed together at different temperatures *.”

SIMILAR experiments performed on a variety of bodies shew, that unequal quantities of absolute heat must be communicated to them in order to raise their temperature, or apparent heat to the same degree.

* Dr. Crawford on Animal Heat and Inflammation; in which work a full explanation of the doctrine of heat will be found, together with a table of the comparative heats of different bodies.

IT is in consequence of their various capacities, that whenever bodies of different species are brought together, a change of temperature is generally produced. Thus, if you mix spirit of wine and water, the mixture will become hotter than the ingredients were before. A much greater degree of heat will be produced by mixing water with vitriolic acid; and, on the other hand, if sal ammoniac be dissolved in water, a considerable degree of cold will be produced.

IN most substances a total change in their state of existence is produced by the superaddition of caloric; thus water is gradually changed from its solid state of ice, into a fluid, and then into an elastic fluid, called vapour, by the addition of different degrees of caloric. And it must be remarked, that this change of state in bodies is attended with a change of capacity for containing caloric; the less dense state containing the greatest quantity of caloric. Thus water in the fluid state contains less

caloric than when it is reduced into vapour, and more than when it exists in the form of ice.

THE aerial fluids are supposed to be combinations of certain substances with caloric. Oxygen air consists of a substance, *sui generis*, which is called oxygen, combined with caloric, and, in all probability, with the matter of light also.

AZOTIC gas consists of a particular substance, called *azote*, and caloric. Common air consists of azotic gas and oxygen air, in the proportion of 73 parts of the former to 27 of the latter. By a mixture of those elastic fluids in the said proportion, an aerial fluid is formed exactly like the atmospherical air *.

HYDROGEN gas consists of a particular substance, called *hydrogen*, and caloric. As

* In general the atmospherical fluid contains a variety of extraneous particles, but they hardly ever exceed the hundredth part of the whole, and seldom amount to that quantity.

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for the particular substances which are frequently found in the hydrogen gas, such as phosphorus, particles of iron, &c.; they must be considered as extraneous matters suspended or dissolved in the gas, but not essential to its constitution.

CARBONIC acid gas consists of a peculiar substance, called *carbon*, or the constituent part of charcoal, and oxygen air, in the proportion of seven of the former to eighteen of the latter.

WATER, which has long been esteemed an elementary substance, incapable of decomposition, has been found to consist of hydrogen gas and oxygen gas, in the proportion of three of the former to seventeen of the latter. By the combustion of those elastic fluids water is actually formed; and, on the contrary, water may be reduced into those aerial fluids, by placing it, under certain circumstances, in contact with bodies that attract one of its components, or by the action of electricity*.

* See Fourcroy's Chemistry, the third volume of my Electricity, and the Phil. Trans. for 1797, P. I.

COMBUSTION consists in the absorption of the base of oxygen air, *viz.* the oxygen, by bodies that are said to be combustible, and setting free both the caloric and the light, which, as has been mentioned above, are the two other components of oxygen air. Agreeably to this definition, we must consider as combustions not only the burning of coals and other fuel, as is usually done in our chimneys, but also the calcination of metals, and respiration itself, since in both those processes an absorption of oxygen, and an evolution of caloric, take place.

IF the calcination of a metal (which is now called *oxygenation* of the metal) is carried on slowly, as by merely exposing certain metals to the atmosphere, then the caloric and the light, which is separated from the oxygen portion of the atmosphere, is too little to affect our senses, and we can only observe, after a certain time, that by having absorbed a quantity of oxygen, the metallic substance has lost its combustibi-

lity (*viz.* its attraction for oxygen) and has assumed a different appearance, together with an increase of weight. If the oxygenation be carried on in a quick manner, as when an iron wire is made very hot in oxygen air, then both the caloric and the light become manifest.

WHEN the metal has absorbed as much oxygen as its nature admits of, it is then said to be incombustible, or completely oxydated. But if by any means the oxygen be separated from it, then the metallic oxyde will be converted again into a metallic substance susceptible of combustion.

IN the combustion of animal and vegetable substances, which consist of various component articles, the process is accompanied with peculiar phenomena, which vary with the nature of the combustible, the quickness of the combustion, and other circumstances. Thus in the burning of wood, the oxygen of the atmosphere is absorbed, the caloric and the light are disengaged,

gaged, the carbon of the wood combines with a portion of the oxygen, and forms carbonic acid gas, the evolved caloric converts the aqueous part of the wood into steam, and so forth.

A VARIETY of phænomena may be obviously explained upon the basis of this doctrine.

WE may easily comprehend why no sort of combustion can take place where no oxygen air exists; as also why every sort of combustion will proceed rapidly in pure oxygen air, and much less so in common air; for the latter contains only a small proportion (*viz.* about one quarter) of oxygen air. Thus may other processes be easily reconciled to, or explained by, this theory. But it is now time to examine the phænomena of respiration.

THE uses of respiration are various and important. They may be divided into mechanical and chymical. Of the mechanical,

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such

such as the voice, the cough, &c. no notice will be taken in this work. The other uses principally consist in furnishing the body with a constant supply of oxygen, and probably in exonerating the blood of the superfluous carbon and hydrogen.

IN the process of respiration a decomposition of the air takes place in the lungs. The blood, in its passage through that organ, absorbs the oxygen of the common air, disengages the caloric, and leaves the azotic gas, with a small residuum of oxygen air. The blood, therefore, does not imbibe the oxygen air, but the oxygen alone, *viz.* the basis of oxygen air, divested of that quantity of caloric which was necessary to give it the aerial form. The caloric which is set free in this process, by dispersing itself through the body, keeps up its temperature, and forms the origin of animal heat. However, this part of the theory which relates to the formation of animal heat, is embarrassed with difficulties, which will be noticed presently.

THE

THE carbonic acid gas, which is formed in the process of respiration, is supposed to derive its origin from a quantity of carbon, which, being discharged from the blood, combines with a portion of the oxygen air.

THE watery vapour which is expelled with the air that is expired from the lungs, is supposed to be formed in that organ by a combination of oxygen with a quantity of hydrogen, which is likewise discharged from the blood. But it is not unlikely that both the carbonic acid gas and the water, instead of being formed in the lungs, may come out of the blood, through the exhaling pores of that organ, ready formed; the blood having originally received it in that state from the chyle, &c.

THE air then which is expired from the lungs, contains a smaller quantity of oxygen air than it did before, but it contains also some carbonic acid gas, and some
water,

water, in the form of vapour*.—Let us now examine the different parts of this theory.

IT is evident, from the foregoing facts and explanations, that the oxygen air is the only fluid capable of assisting respiration and combustion, and that it is indispensably necessary to animal life, since the common air is useful only on account of the oxygen it contains.

* There are some modern philosophers, who explain the phenomena of respiration without admitting the absorption of oxygen by the blood. The blood, they say, in passing through the lungs, acquires a vermilion red colour, because it deposits a portion of its carbonated hydrogen upon the air; and it becomes again dark in the course of circulation, because it combines with a fresh quantity of carbonated hydrogen. At the same time the oxygen of the common air which enters the lungs, by combining with the carbon and with the hydrogen, forms the carbonic acid gas with the former, and the watery vapour with the latter.—It may be easily perceived, that by only changing the name of carbon into that of phlogiston, this explanation may, in a great measure, be made to coincide with Dr. Priestley's hypothesis.

THE

THE mixture of nearly one part of oxygen air and three parts of azotic gas, which forms the atmospherical fluid, is, in all probability, the best proportion of ingredients for the maintenance of life ; since we find that with a smaller proportion of oxygen, not only the respiration becomes unpleasant and laborious, but debility, convulsions, and other bad effects are produced ; and on the other hand, that bad symptoms of another sort are brought on by a greater proportion of it, such as a preternatural heat, feverish pulsation, pains, inflammations, &c.

THE phænomena of respiration and of combustion are not only analogous, but they illustrate each other in an admirable manner. In atmospherical air a candle gives light sufficient for ordinary purposes. In a less pure atmosphere the light becomes too dim ; and in pure, or nearly pure, oxygen air, the candle will indeed give a much brighter light ; but it will waste so very fast, as not to last perhaps the twentieth part of the time it will in common air.

THAT

THAT the blood absorbs the oxygen of the atmospherical air in the act of respiration, is a proposition which a variety of experiments and analogies seem to prove beyond all doubt. When blood, recently taken out of the veins of an animal, is enclosed in a piece of bladder, and is thus exposed to common air, or to oxygen air, it acquires a florid red colour, and part of the oxygen air is absorbed. The same thing takes place within the body, *viz.* the air which is expired contains a smaller proportion of oxygen than it did before, and the blood which returns from the lungs to the heart, and thence proceeds through the arteries, is found to have acquired a bright redness in its passage through the lungs; it is therefore natural to conclude, that the blood has absorbed the oxygen through the pores of the thin membrane, which separates it from the air in the cells of the lungs *.

* This membrane is certainly much thinner than common bladder. Dr. Hales conjectured the thickness of the former to be the thousandth part of an inch.

THE probability of this conclusion is corroborated by strong collateral proofs ; as by observing that the arterial blood of animals that have been suffocated, or that have died for want of oxygen air, is far from being of its usual florid red colour ; as also by observing, that when a quantity of blood is confined in a vessel full of air, the air is not so quickly contaminated or deprived of its oxygen by the presence of arterial, as by that of venous blood. And it is even asserted, that a quantity of blood taken out of the carotid artery of a sheep, being confined in a vessel full of azotic gas, improved the gas so as to render it, in some measure, fit for respiration, so that some oxygen must have been imparted to it by the blood *. This experiment deserves to be repeated with particular care.

THE decomposition of air, and the absorption of its oxygen in combustion and oxygenation of metallic bodies, are also ana-

* Medical Extracts, vol. I. p. 70.

logous to the phænomena of respiration, and confirm the absorption of oxygen by the blood in that process.

It is true that a small quantity of carbonic acid gas is found in the air in which blood has been confined; but the formation of this gas does not entirely account for the diminution of the oxygen. Besides, it is not improbable, as we said above, that the carbonic acid gas comes out of the blood ready formed, at the same time that the blood absorbs the oxygen.

By examining the course and state of the blood, we find that it preserves its brilliant redness through all the channels which convey it from the lungs through the heart, and to the extremities of the body. But in the other vessels, which receive it at the extremities of the former, and convey it through the heart as far as the lungs, the blood is of a dark purple colour. The former course is performed through the pulmonary veins, the left auricle and left
ventricle

ventricle of the heart, the aorta and its branches. The latter is performed through the branches and trunks of the ascending and descending cava, the right auricle and right ventricle of the heart, and lastly, through the pulmonary arteries, which convey it to the spongy cells of the lungs, where its colour is changed, &c.

THE blood, therefore, having acquired the oxygen in the lungs, conveys it as far as the extremities of the branches of the aorta, where the oxygen is deposited, and the blood returns without it through the veins.

IT is difficult to say under what form is the oxygen combined with the blood, and what becomes of it at the extremities of the arteries where it is left by the blood. For want of direct experimental information concerning this interesting point, we have only the light of analogy and conjecture to lead us in the investigation of truth.

IN

IN the combinations of the base of oxygen air with different bodies, such as take place in combustions of every sort and degree, three different effects must be particularly remarked. The first is, that the oxygenation is generally accompanied with colours of different intensity; the red being produced more frequently than any other colour, as is the case with *mercurius calcinatus per se*, red lead, *crocus martis*, &c. The second is, that by the accession of oxygen a body is always rendered firmer or more compact. Thus, by the combustion of hydrogen and oxygen, water is produced, which is a much heavier and more compact substance than either of its two components; thus also by oxygenation oils are thickened, and metallic bodies are converted into a substance powdery indeed, but whose particles are firmer and harder than the same bodies in their metallic state *. The third is, that a body loses, in
great

* It is in consequence of the superior hardness of its particles, that *crocus martis* (which is oxygenated iron) and

great measure, its capacity for containing caloric, and of course gives out heat whenever it passes from a rare into a more compact state of existence, and *vice versa*. Thus water contains a great deal more of caloric than ice, but much less than steam; hence when steam is converted into water, it deposits part of its caloric, *viz.* it communicates sensible heat to the surrounding bodies, &c.

By an easy application of those facts to the phænomena of respiration, we are led to conclude, first, that the redness which the blood acquires in the lungs, indicates a real oxygenation of that fluid; secondly, that the oxygen is slightly attached to the blood, for the blood easily parts with it at the extremities of the arteries; thirdly, that the oxygen, which is deposited by the blood at the extremities of the arteries, enters into combination with, and gives firm-

and the oxyde of tin (commonly called *putty*) are employed for polishing the hardest steel, glass, and even agates.

ness and solidity to, those particles of matter which give increment and stability to the animal frame ; fourthly, and lastly, that as the bond of union between the blood and the oxygen is not very strong, and as the union of the oxygen with other substances at the extremities of the body is much stronger, therefore it seems evident that the caloric of the oxygen air is not entirely evolved from it in the lungs ; but that the greater portion of caloric is evolved at the extremities of the arteries, where the oxygen is more powerfully attracted by other substances than it is by the blood in the lungs. Hence it follows, that the origin of animal heat does not exist in the lungs only, but that it takes place, more or less, in every part of the body. And this shews why the whole body is nearly of the same temperature ; whereas, if the caloric were evolved in the lungs only, that part of the body would be much warmer than any other, which is not the case *.

WHAT

* I am happy to find that this explanation coincides with the opinion of a very distinguished and recent anatomical

WHAT disposes the blood to absorb the oxygen in the lungs, and what forces it to deposit that principle at the extremities of the arteries, are questions which the present state of knowledge does not enable us to answer satisfactorily. It has been supposed that the oxygen is attracted by the ferruginous particles of the blood, and that the redness of the blood is to be attributed to the red colour of the oxyde of iron. But
since

tomical writer, who expresses himself in the following words :

“ But in reflecting upon this most difficult of all subjects, the generation of heat in the living body, many things are to be taken in the calculation, which seem, on the slightest glance, to be far more important than this deposition of oxygene from the blood. It is a law of nature, to which, as far as we know, no exception is found, that a body, while it passes from an aerial to a fluid, or from a fluid to a solid form, gives out heat. Now, what is the whole business of the living system but a continual assimilation of new parts, making them continually pass from a fluid into a solid form ? The whole nourishment of the body goes on in the extreme vessels, and is a continual assumption of new parts. The extreme vessels are continually employed in forming some acids, which appear naked in the secretions ; in forming

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since it has been proved by a variety of experiments, that the oxygen is attracted by, and combines with, a variety of other substances independant of iron or metals, I do not see the necessity of attributing the attraction of the oxygen to the ferruginous, more than to other, ingredients of the blood. Nor do I see the absolute necessity of attributing the red colour to the particles of iron, since other substances, in which iron is not concerned, such as the oxyde of mer-

oxyds, as the fat and the jellies of the membranous and white parts ; in the various depositions of muscle, bone, tendon, &c. for these are all continually absorbed, thrown off by the urine, and incessantly renewed. They are continually employed in filling all the interstices of the body with a bland fluid or halitus ; they are continually employed in forming secretions of various kinds. In performing all this the power of the vessels may do much ; but the ultimate effect in each process must be a chemical change, and perpetual changes will produce a constant heat. Place the organ and focus of this animal heat in the centre of the body, and you are embarrassed in a thousand difficulties ; allow this heat to arise in each part according to its degree of action, and each part provides for itself." Bell's Anatomy, vol. II. p. 125.

cury,

cury, red lead, &c. owe their redness merely to the oxygen which they have imbibed.

It is difficult to account for the formation of the carbonic acid gas, and of the watery vapour in the lungs; for if those fluids be really formed in that organ by the combination of the carbone, and of the hydrogen, with the oxygene of the inspired air; the whole, or nearly the whole, of the oxygen air would be so expended, and little or none of it would remain to be imbibed by the blood. The caloric likewise would be employed in the formation of those fluids, instead of being dispersed through the body. Is it not therefore more natural and more satisfactory to suppose, that both the carbonic acid gas, and the water, are separated from the blood in the lungs, but not formed in that organ? It is certain that carbonic acid gas is introduced into the stomach by the aliments; and it is certain that the chyle conveys it to the blood, why then should we suppose that there is another formation of this gas in the lungs? As for the

watery vapour, we may account for it in the same manner; and indeed the exudation of water through the internal membranes of the human body, is so generally practised by nature for the purpose of keeping those membranes, &c. soft and pliant, that it would be irregular not to admit the same exudation of water in the lungs also.

THE expulsion of putrid effluvia from the body is considered as another office of respiration. This is shewn by the offensive smell of the breath of certain persons, who have no bad teeth to account for it. But it is difficult to ascertain in what cases this may take place, and how far it may extend.

IT is with the appearance of probability supposed that the oxygen, which the blood deposits on the various parts of the body, is partly expended in the exercise of muscular motion; since we find, that after unusual exertions of the body, a man breathes faster, and likewise takes in much more air at a time, as if nature endeavoured by that means

means to recruit what has been lately expended in greater quantity than usual.

THE azotic gas, which is the greatest ingredient of common air, is considered as only a diluent of the oxygen air, and as being otherwise passive in the process of respiration. Yet this diluent answers a variety of purposes; the principal of which is, that it exposes a proper quantity of oxygen air to a great quantity of blood, which could not have been the case if the atmospheric fluid had consisted entirely of oxygen. This object is accomplished by the very extensive surface which the lungs present to the air in its numerous cells; for the more numerous the cavities are, the greater is the surface; and, in fact, we find that in those animals that are not much in want of air, and that must frequently suspend their respiration for a considerable time, such as the sea-turtle and the frog, the lungs consist of very few and very large cells.

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THE great proportion of azotic gas in common air, does also adapt that fluid to the purposes of vegetation, and other natural processes, the enumeration of which is incompatible with the limits of this Essay.

CHAPTER VI.

A general Idea of the Application of aerial Fluids for the Cure of Disorders incident to the human Body.

CONSTANT observation has informed mankind, from time immemorial, that the air of certain places is more or less salubrious than that of other places ; and that the various qualities of the air in different situations, are peculiarly favourable to certain constitutions. Physicians, availing themselves of this natural variety, have
long

long been in the habit of sending their patients to such places as experience and analogy indicated to be more favourable to their respiration. The sharp air of one place was reckoned good for one disorder, the damp air of a second place was esteemed useful in other cases, the pure air of a third was recommended in particular diseases, and so on. Howsoever defective and erroneous their knowledge of the real constitution of the atmosphere may have been, howsoever they may have abused the application, yet certain it is, that the variety of effects, suitably to the different qualities of the atmospherical fluid in different situations, is attested by innumerable facts and universal observation. Previously to the late discoveries, the ideas of physicians respecting the different qualities and effects of the atmospherical fluid, were vague, and generally erroneous. Experience, which shewed them the advantages that had been obtained in a number of similar cases, was their best guide, and all besides was doubt and obscurity. The present state of knowledge has, in great measure,

measure, dissipated the clouds ; since it has not only shewn the reasons upon which certain qualities of the air depend, but has likewise furnished us with the means of procuring airs of opposite qualities, and of any degree of purity, at all times and places, as also of applying them in all the extensive variety of quality, degree of purity, and length of time.

THE apparatus necessary for producing the various factitious airs, may be easily derived from the particulars that have been mentioned towards the beginning of this book ; but for a general apparatus, that admits of compactness, cheapness, and a sufficiently extensive application, I cannot recommend any better than, or nearly so good as, that which was contrived by Mr. James Watt, engineer, of Birmingham ; by means of which the artificial airs, of sufficient purity, may be produced at a very moderate expence, and easier than by any other general method. Those apparatuses are now made for sale, and a printed description, with

with necessary practical directions for the use of its various parts, is given with each apparatus, which supercedes the necessity of adding the same to the present work. I shall, nevertheless, reserve, for the end of the book, a list of the principal precautions which should be attended to in the management of Mr. Watt's, or of any other apparatus of this sort, to which the practitioner may recur for extempore information.

THE artificial elastic fluids are applied to the lungs by the way of respiration, to the stomach and intestines, by means of injections, or in combination with fluids, and to the external parts of the body, merely by contact.

VARIOUS apparatuses have been used for the respiration of factitious airs. The least exceptionable air-holder for this purpose, consists of a large glass receiver filled with the required sort of elastic fluid, inverted, and swimming in water ; out of which the

air is respired by means of a bent glass tube, which, passing with its bent part through the water, projects one aperture above the water within the receiver, whilst its other extremity is applied to the mouth of the experimenter,

INSTEAD of the above-mentioned bent tube, the receiver may have an aperture at its upper end, to which a tube is adapted, air tight, in an horizontal direction. But as this apparatus requires a large tub full of water for the receiver to swim in, which renders it rather cumbersome, and not very portable, therefore other contrivances have been substituted to the receivers. The machine more in use for this purpose, consists of an oil-silk bag, furnished with a short wooden tube or faucet, which, when the bag is full of the required aerial fluid, is applied to the mouth of the patient. Those bags are filled with the proper aerial fluid by means of a glass receiver, which, besides its large aperture, has a small aperture with a stopple at the opposite end. The receiver
being



being filled with the required air, and inverted in water, the stopple is removed from its small aperture, and the wooden tube of the bag is applied quickly to it; then by pressing the receivers down into the water of the tub, the air will be forced into the bag. But with the air-holders, which form part of Mr. Watt's apparatus, the operation is rather easier, for which, see the description of the said apparatus. The principal imperfection of these bags consists in the smell of the oil-filk, which proves nauseous, and almost intolerable to delicate persons; yet this smell may, in some measure, be removed*.

INSTEAD

* For this purpose Mr. Watt gives the following directions:—"To free oiled filk from its disagreeable
"smell, cut it into pieces of the size wanted for the
"bags, and provide a smooth table somewhat larger
"than the pieces of filk, and a flat board of the same
"size as the table. Take charcoal fresh burnt in an
"open fire, until it is free from smoke, extinguish it by
"shutting it up in a clean close vessel, and reduce it to
"powder. Sift this powder over the table to the
"thickness of a quarter of an inch, or more, spread a
"piece

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INSTEAD of oil-filk bags large bladders may be used; but as a bladder is not capable of holding a quantity of elastic fluid large enough for medicinal use, several of them should be had in readiness, each fur-

“ piece of your filk upon it, and sift upon that again ano-
 “ ther layer of your charcoal dust, and thus proceed al-
 “ ternating the layers of filk, and charcoal, until the
 “ whole of your filk is deposited; then lay your move-
 “ able board upon the top of all, and leave the whole
 “ undisturbed for four or five days. If, upon remov-
 “ ing the charcoal dust, the filk has not lost its smell en-
 “ tirely, repeat the process. The charcoal dust is to be
 “ swept off the filk, and the filk to be washed upon a
 “ table with a wet sponge until it is clean. The bags
 “ must then be carefully sowed up, and the seams
 “ anointed with japanner’s gold size, taking care to use
 “ that kind which does not become brittle when dry.
 “ Green oiled filk should be avoided, as it is stained by
 “ means of verdigris, which rots it; the yellowish filk
 “ is the best.

“ It is necessary to observe here, that although oiled
 “ filk be the best substance known for making the bags
 “ of, it is very imperfectly air-tight; and although
 “ charcoal-dust deprives it of smell for the time, yet as
 “ it can only attract the odoriferous particles from the
 “ surface, it re-acquires some smell by keeping, but by
 “ no means equal to what it had at first.”

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nished with a wooden or glass tube, like the oil-filk bags, through which they may be filled, &c.; so that when the air of one bladder is exhausted, a second bladder may be substituted, and so on. Several bladders might be easily made to communicate with each other, so that through one tube or faucet they might be filled all at once: four or five large bladders thus joined together, would contain about as much air as an ordinary oil-filk bag, which is a quantity, in most cases, sufficient for one application, and it would last about six minutes. The bladders have likewise an unpleasant smell, which may also, in great measure, be removed*.

WHETHER the glass receiver, or the oil-filk bags, or the bladders be used, the patient must always take care to keep his nostrils accurately stopped whilst he draws

* For this purpose turn the bladder inside out, wash it well with a weak solution of salt of tartar, then wash it several times over with fair water, so as to remove every particle of alkali; lastly, wash it with spirit of wine.

the

the air into his lungs at every inspiration, and to open them immediately after, so as to expel the air from his lungs through the nostrils into the atmosphere at every expiration, and not to return it into the bag or receiver. This operation is not easily performed by most persons, and some there are who cannot perform it at all; in which case they breathe the same air backwards and forwards to and from the bag. But by this means the air of the bag, even when lime-water is contained in it, is contaminated so quickly as to do more harm than good.

THIS inconvenience, however, is completely obviated by the use of a little machine, which is to be interposed between the mouth of the patient and the faucet of the bag. It consists of a small box of wood, having three apertures, to the two opposite of which two short tubes are fastened; to the third, which is a lateral one, there is an external valve which will only permit the air's going out of the box into the atmosphere. One of those tubes is applied to
the

the faucet of the bag, and it contains a valve which prevents the return of the air into the bag; the other tube is applied to the mouth of the patient, who has nothing more to do than to hold his nostrils constantly stopped, and to breathe in a natural way as long as there is any air in the bag or receiver *; it being easy to understand that whenever he inspires, the air will pass from the bag into his lungs; but that at every expiration, the air will be forced through the lateral valve of the machine into the ambient air.

OF the various sorts of elastic fluids, the carbonic acid gas is the only one that has been successfully applied to the stomach or intestines, and for this purpose it may be administered two ways, *viz.* either in the aerial form in clysters, or combined with different fluids and given through the

* There are several persons who, with very little attention, can breathe through the mouth only; when this is the case, the keeping of the nostrils stopped is superfluous.

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mouth.

mouth. For the former of those purposes the gas must be first introduced into a bladder by the method already described. For the latter, the gas is either naturally contained in liquors, as in newly fermented liquors, yeast, certain ripe fruits, and mineral waters; or is to be first combined with the required liquors, in which case water is the fluid which is more generally used. This impregnation of water and other liquors with carbonic acid air, may be accomplished by various methods, such as by pouring the liquor backwards and forwards from one vessel to another, over the surface of vegetable substances that are in a strong state of fermentation; or by filling a vessel partly with carbonic acid air, and partly with the required liquor, and then shaking it for a minute or two, &c. But the best way of performing this impregnation, is by means of a well-contrived machine, which has been long in use, and is generally known under the name of Dr. Nooth's glass apparatus, for making artificial mineral waters. There is, however, a contrivance for impregnating

pregnating water with an incomparably greater quantity of carbonic acid gas, than that which can be accomplished in Dr. Nooth's apparatus. But this contrivance is kept a secret by the inventor, though the water, so highly impregnated by him, may be had in London at a moderate price.

THE application of factitious airs to the external parts of the body, may be performed with the utmost facility. The aperture of a tube, which proceeds from the vessel in which the gas is generated, may be directed towards the part which is affected; a bladder full of the required gas may be gradually pressed, so as to throw a stream of the gas upon it; the part itself, as far as it is practicable, may be introduced into a vessel full of the required air; or, lastly, a small glass funnel, with a bladder fastened to its small end, and filled with the required elastic fluid, may be applied over the part, with the edge of its large aperture close to the skin, so as to prevent the escape of the gas into the circumambient air.

THE medical application of factitious airs, and the effects which have thereby been produced, are as yet labouring under all the vicissitudes of truth and exaggeration, of accuracy and misapplication, of short experience and uncertainty. The anxiety of some persons, the ignorance of others, the desire of fame, the love of interest, and the fear of dangerous innovations, have alternately operated in favour and against the administration of the elastic fluids for the alleviation of disorders incident to the human body. In the conflict of such opposite powers, it is difficult to separate truth from exaggeration and error; it is impossible to ascertain the precise limits of their use and efficacy.

NOTWITHSTANDING those weighty objections, I have endeavoured to collect, to examine, and to methodize all the useful information which I could procure relatively to the subject, in hopes that a comprehensive view of it might promote the use, and in great measure prevent the abuse,

abuse, of a new class of remedies, which have all the appearance of proving very advantageous to mankind.

IN the use of oxygen air we have a singular stimulus, which admits of its being rendered more or less active by dilution with various proportions of common air. In its pure, or nearly pure, state, it is a powerful exciter of suspended animation; and when diluted with a considerable quantity of common air, it is a gentle stimulus, which, by invigorating the various parts of the animal body, by communicating firmness to the solids, and energy to the fluids, does frequently obliterate the causes of morbid habits.

THE use of azotic gas, and of the various species of hydrogen gas, produces a diminution of the irritability of the animal fibre to any degree, and hence it becomes useful in a variety of those disorders, which depend on an increased irritability, such as inflammations, coughs, spasms, &c.

IN the use of the carbonic acid gas we have a powerful antiseptic, and in certain cases a solvent of considerable efficacy.

THE use of pure oxygen air is confined to the purpose of exciting the dormant powers of suspended animation, and it is, therefore, to be administered to children born apparently dead, or overlaid; to persons suffocated by drowning, by steam of charcoal, by foul air, &c. whenever the circumstances of the case may indicate a possibility of recovery.

THOSE cases excepted, the respiration of pure, or nearly pure, oxygen air, is almost always attended with unfavourable symptoms, such as a preternatural heat, especially about the region of the lungs; a quickened and feverish pulsation; inflammation, &c. And those symptoms come on after a shorter or longer use of the oxygen air, according to the particular constitution of the experimenter, and the purity of the gas.

BUT

BUT when the oxygen is diluted with much common air, *viz.* in the proportion of one to eight, and even as far as one to twenty, it then is a safe and very useful remedy, whose principal action consists in giving tone, elasticity, and consistence to the fluid as well as to the solid parts of the body, and of course it promotes all the natural consequences of those effects, *viz.* it quickens languid circulation, it strengthens the organs of digestion, promotes secretions, invigorates debilitated habits, and it assists nature in throwing off bad humours, and other lurking causes of diseases.

IT has been observed, that some individuals can bear a much greater proportion of oxygen than others, which is analogous to the various dispositions for all other applications. Thus a certain quantity of any remedy will act powerfully on some persons, whilst it will not be even felt by others. Thus also a certain quantity of food produces strength and cheerfulness in some individuals, whilst it produces sickness and

H 4 indigestion

indigestion in others. It therefore becomes necessary, in the application of this remedy, to regulate the proportion of the two elastic fluids agreeably to the constitution of the patient, which may be easily accomplished by means of a very few trials.

IN the diluted state, the oxygen air is administered by letting the patient breathe it for five or ten minutes once or twice a day. It might probably prove more efficacious, if it were breathed in a more diluted state for a longer time; but the preceding mode has undoubtedly been attended with salutary effects.

HOWEVER slight this application may appear, however small the unusual quantity of oxygen which is thus introduced may be, the effects have been proved and confirmed by a variety of experiments and medical cases. But independent of the experimental proof, the improbability of the effect will disappear if it be considered, that the lungs of most persons, and especially of those who labour under certain diseases,

are almost immediately relieved or affected by the transition from the air of one place to that of another ; as by their going out of town, or even out of the house ; and yet, as has been already observed, the difference between the air of a town and the air of the country, or of that of a house and of the external air, is so very trifling as hardly ever to be distinguished by the eudiometer. Extremely minute, and almost inconceivably small, quantities of matter can act with wonderful efficacy, when they are introduced into the circulation of the blood. The inoculation of the small-pox, and the experiments with poisons, furnish sufficient confirmation of this observation.

By breathing a mixture of common and oxygen air, even when the latter does not exceed one-eighth part of the former, for about ten or fifteen minutes, the pulse is generally quickened of a few strokes, but it is almost always made stronger. The lungs, during the operation, are seldom sensibly affected ; but on leaving off the mixed airs,
and

and returning to the atmospherical air, a degree of tightness is frequently felt on the chest, which, however, gradually goes off and vanishes after a few minutes time.

WHEN debilitated habits breathe the diluted oxygen air for about a quarter of an hour once or twice a day, the improvement of their health is hardly ever conspicuous in less time than a week or a fortnight; but after that period, they will find their strength, their appetite, their digestion, their circulation, and other functions, sensibly improved; and this improvement goes on progressively to a greater or less degree, according as age, local indispositions, times of the year, and other circumstances may allow.

THE mixtures of common air with azotic gas, or of common air and any species of hydrogen gas, are commonly denominated *reduced atmospheres*; for, in fact, they contain a smaller quantity of respirable fluid, than is contained in an equal quantity
of

of common air. The principal effect of those reduced atmospheres, is to diminish the irritability of the parts subservient to respiration, and indeed of the whole body; for which reason they are successfully administered in inflammations of the lungs, in spasmodic coughs, and in all the disorders that are nearly allied to those.

MUCH caution must be used in the administration of those reduced atmospheres, as some of them are productive of alarming symptoms. The mixture of azotic and common air, in which the former should never be more than a quarter of the latter, is the least dangerous, and at the same time the least efficacious. The same thing may be said of the mixture of common air with the mild sort of hydrogen gas, *viz.* that which is produced from iron and diluted vitriolic acid, or by passing the steam of water over red hot iron, excepting that it is rather more efficacious than the preceding. But the hydrocarbonate is much more powerful and more dangerous than
any

any of the abovementioned gasses, especially when fresh made. It should, in general, be mixed with about twenty or thirty times its bulk of common air, unless some particular case may seem to require a greater proportion of the dangerous gas. For most purposes it will suffice to breathe it for about five minutes a day.

THE breathing of the diluted hydrocarbonate is attended with a diminution of sensibility, especially about the chest, and this effect is frequently so great, that some persons have expressed it by saying, that they felt as if they had no lungs at all, even when they had been a few minutes before in excruciating pains. But this diminution of sensibility is almost always accompanied with vertigo or giddiness, with a lowering of the pulse, and with faintness. It must be particularly remarked, that though those symptoms in general come on immediately after the operation, yet sometimes they return once, and even twice, more in the course of the day. When the breathing of
reduced

reduced atmospheres proves very troublesome, it may be interrupted for a few minutes.

ITS great power in checking irritability and sensibility, seems to render the diluted hydrocarbonate applicable to some disorders that have hitherto eluded all medical application; and as one of the most likely to be relieved by this treatment, I shall mention the hydrophobia, or madness which is occasioned by the bite of mad dogs, or other mad animals *.

A REDUCED atmosphere, capable of diminishing in some degree the irritation of the lungs in inflammations, coughs, and

* I have been told, and have read, though I cannot at present recollect where, that the use of opium, and likewise that the suspension of animation for a time by accidental drowning, have actually cured the hydrophobia in two or three cases. If this be true, the probability of the hydrocarbonate proving beneficial, is thereby much increased.

certain

certain species of asthma, has been expeditiously formed by mixing the vapour of vitriolic ether with common air. For this purpose the patient needs only hold a small phial of ether open near his mouth, for about an hour at a time or longer, by which means the vapour of the ether mixes with the air that enters the lungs in the usual course of respiration, and converts it into an inflammable, or rather an explosive, aerial fluid *. For this purpose it has been found useful to mix some powdered leaves of hemlock (*cicuta*) with the ether. The ether (*viz.* about a quarter of an ounce of it) may also be put in a common tea-pot, and the mouth may be applied to the spout of it, so as to draw the air through it, and through the vapour of the ether.

THE carbonic acid gas has been longer in use as a medicine than any other facti-

* If three or four drops of ether be shook in a phial full of common air, and if afterwards the aperture of the phial be presented to the flame of a candle, the air in it will explode like a mixture of common air and hydrogen gas.

tious aerial fluid. Much has been done, and much has been written, relatively to it. But the useful result of those experiments and investigations will be found condensed in the following few paragraphs.

IN putrid fevers the free use of carbonic acid gas has been of considerable use, whenever the urgency of the case has not been very great, *viz.* when time was allowed for the gas to operate upon the morbid matter; and when the distention of the bowels was not so great as to prevent the free use of the gas.

IN the scurvy this gas has been of considerable use in the beginning of the disorder, rather more than in an advanced state of it. But the use of vegetables, of sugar, and of other substances that contain it in great abundance, are acknowledged to be useful in all states of that disorder. Experience likewise informs us, that in the use of carbonic acid gas we are not to expect an unlimited antiseptic, nor a perfect solvent of
the

the stone in the urinary bladder ; yet its use in putrid cases, and in some diseases of the bladder or kidneys, is attended with considerable benefit.

THE external application of carbonic acid gas to sores and ulcers of every sort, is unquestionably very useful.

AFTER a careful consideration of the preceding general and comprehensive prospect of the medicinal use and efficacy of the aerial fluids, we may easily regulate the measure of our hopes by the standard of reason and experience. The idea of finding in them a remedy, capable of curing consumptions in all their stages, must be laid aside ; and the hope of healing all sorts of internal ulcers will naturally vanish. The use of reduced atmospheres does undoubtedly diminish the irritability of the fibre, and a diminution of irritability favours the healing of certain ulcers, but by no means of them all ; nay, in some cases it will even produce the contrary effect. The use of
oxygen

oxygen air has been found advantageous in many of those disorders that are called nervous, and it has undoubtedly strengthened and invigorated several debilitated or emaciated habits; but it would be absurd to expect that it should prove beneficial in all cases of emaciation and debility, since those visible effects are often produced by causes that may be rather fomented than checked by the use of oxygen air.

IN most of the disorders incident to the human body, the various concurring circumstances are far from being known to their full extent; hence theory may suggest, but experience must prove the use of certain practices. Improvements and discoveries may be generally urged and expected; but where theory and experience are silent, we have no warrantable guide to assist us in the investigation of new properties and new applications.

CHAPTER VII.

Of the particular Administration of aerial Fluids in different Disorders.

AFTER a general idea of the application of factitious airs by way of remedies to the human body, it will be necessary to state those modes of treatment, which experience or analogy shew to be the most efficacious in particular diseases. But this statement cannot be attended either with great accuracy of description, or with extensive information concerning the phænomena, that are really produced by the factitious airs in all cases. The various nature of individuals, the imperfect accounts of several cases, and the frequent administration of other medicines in conjunction with the aerial fluids, limit for the present the attainment of the abovementioned objects.

ALL

ALL that the practitioner may expect to derive from the present chapter is, a guide or indication for the commencement of the application, a general view of the principal effects that are produced by the particular administrations, and a warning against mistakes. But with respect to the continuation, or suspension, or alteration, of the treatment, he can only be instructed by a careful observation of the phænomena which take place in the course of the application.

I SHALL forbear mentioning other medicines that may be proper to be administered at the same time with the gasses, as these must be left to the judgment of professional gentlemen. But I would strongly recommend to administer them as sparingly as the nature of the case can possibly admit of; being persuaded, that the good effects of the aerial fluids is frequently counteracted by the action of other medicines.

N. B. The diseases in the following pages are arranged in alphabetical order.

Animation suspended.

IN cases of this sort, whether they be occasioned by drowning, by noxious vapours, or by any other cause of the like nature, the oxygen air should be administered pure, or nearly so. The wooden pipe of a large bladder full of it must be introduced into the mouth of the subject, the lips must be pressed upon the said pipe, and the nostrils must be stopped by the hands of an assistant. Then by pressing the bladder, the oxygen air must be forced into the lungs, as much as possible, for about eight or ten seconds, after which the mouth and nostrils being unstopped, without removing the pipe of the bladder, the chest about the region of the lungs must be pressed gently; then the bladder being applied as before, the oxygen air is forced again into the lungs, and so on; continuing a sort of forced and artificial respiration for about a quarter of an hour at least, if no signs of
life

life appear before that time *. But as soon as any natural or spontaneous movements are perceived, the pressing of the region of the lungs may be discontinued, and the bladder, &c. must be removed ; for in that state a free ventilation of the ambient air will be found sufficient to restore life.

THIS treatment should be accompanied with the communication of a gentle warmth, and perhaps with friction to the hands and feet. But care must be taken to do what is just necessary, and not too much ; for in the attempts to restore animation, the stimuli and other applications are frequently carried so far, as to destroy that last spark of life, which they were intended to revive.

IN cases of children born apparently dead, or strangled in laborious parturition, &c. the use of oxygen air cannot be too forcibly recommended. The application is easy and highly promising. Independent of

* Several bladders full of oxygen air should be kept in readiness, for a single bladder will be soon exhausted.

the experiments that have been made on brutes, I know of a case, in which a child born apparently dead, was brought to life merely by forcing oxygen air into his lungs, whilst he was held before the fire.

Asthma.

I FIND many creditable accounts of this disorder having been relieved, and sometimes perfectly cured, by the use of diluted oxygen air in some cases, and by the use of reduced atmospheres and the vapour of ether in other cases.

IT would be absurd to imagine, that either of those treatments may be indiscriminately applied to the very same species of asthma; but the distinctions are not clearly stated in all the accounts of the cases. It appears, however, that in a plethoric asthma, and when the disorder is attended with considerable pain, hard cough, and inflammatory symptoms, the reduced atmospheres must be administered.

IN

IN those cases the patient may be directed to breathe daily sixteen quarts of common air, with four quarts of hydrogen, obtained from iron and diluted vitriolic acid, or, which is better, from the vapour of water and red-hot iron. But should this mixture of elastic fluids prove ineffectual in a day or two, then a mixture of one pint of hydrocarbonate and thirty pints of common air, may be used instead of it; and the strength of this mixture may be increased according to circumstances. If in breathing the diluted hydrocarbonate, giddiness should come on, the patient must be desired to intermit the operation; resting, that is breathing the ambient air, for a few minutes, and then to resume the inhalation of the diluted hydrocarbonate. Thus the operation may be intermitted three or four times.

THE breathing of the vapour of ether, after the manner described in the preceding chapter, has been found to afford considerable alleviation of the pain and oppression in those cases.

IN nervous asthma, and especially in debilitated habits, the oxygen air may be administered ; and it will be proper to begin by inhaling daily eight quarts of common, with two quarts of oxygen, air, extracted from manganese by means of heat. The quantity of oxygen may be increased, in case the abovementioned proportion should be found ineffectual ; and it is remarkable, that in this species of disease the patients can sometimes bear a great quantity of oxygen without any material effect.

IN all cases of asthma, the effects of the application of factitious airs may be perceived in the course of four or five days ; but the accomplishment of the cure will frequently require six weeks time, or longer.

Cancer.

THE stubborn nature of a cancer, and its dreadful consequences, render every hint, that promises an alleviation of its effects, extremely interesting.

THE

THE elastic fluids have been repeatedly applied to cases of this sort, and such applications have been attended with considerable advantage. I do not find any authentic account of a cancer having been completely cured by the use of factitious airs. But certain it is, that in a variety of cases the pain has been considerably diminished, the fœtor as well as the bad aspect of the ulcer, have been almost entirely removed, and the whole habit of body has been considerably improved, so that the patients have thereby been enabled to have comfortable nights, more cheerful countenances, &c.

THOSE good effects have been produced by the external application of carbonic acid gas to the ulcer, and the inhalation of diluted oxygen air. Both those elastic fluids must be administered daily for weeks, or as long as the indications of the case may afford a hope of melioration. The manner of applying the carbonic acid gas has been
already

already described *; as for the continuance of the application, an hour a day is by no means too much, and it would be better if such an application were repeated two or three times in the course of each day. With respect to the oxygen, two or at most three quarts of it, with about fourteen or sixteen quarts of common air, may be sufficient for each daily inhalation.

Catarrh.

IN colds and defluxions, especially when accompanied with tightness about the region of the lungs, and a hard cough, much and almost instantaneous relief has been frequently obtained by breathing a mixture of about four quarts of hydrogen and twenty quarts of common air. There is no need of breathing this quantity at once. It will hardly ever be necessary to repeat this application longer than the third day. The breathing of the vapour of ether in the

* See chap. VI. p. 99.

manner already described, will answer nearly as well as the above-mentioned mixture of elastic fluids, and it has the advantage of being a much easier application, since it requires no particular apparatus *.

Chlorosis.

THE administration of diluted oxygen air has proved beneficial in diseases of this kind, perhaps more often than in any other disorder, as is proved beyond a doubt by several authentic cases. The paleness, the debility, the palpitation, the fever, the depraved appetite, and the other bad symptoms which accompany this disorder, generally begin to diminish in about four or five days, and a complete cure is often accomplished in about six weeks time.

THE daily inhalation of one quart of oxygen, and ten or twelve quarts of common, air, may suffice for the beginning. But it

* See chap. VI. p. 110.

is to be remarked, that chlorotic patients are sensible of the least excess in the proportion of oxygen, so that sometimes they are more hurt than benefited by it, unless such a quantity of it be administered as may be just necessary; and this quantity can be shewn only by a careful observation of the effects which take place. The lungs will be enabled to bear the stimulus of oxygen air every day better and better.

Consumption.

THE various states of consumption, or *phthisis pulmonaris*, its different causes, and the difficulty of discerning a real phthisis from certain other disorders, render the treatment of this disease frequently doubtful and perplexing. But its stubborn nature, and the frequency of the disease, demand the utmost attention, and all the assistance which philosophy can suggest, and the medical art can apply. We shall therefore endeavour to state, how far the use of factitious airs has been found useful or promising in cases of this nature.

It has been said on one side, that the factitious airs have the power of arresting the progress of consumption, and often of accomplishing a perfect cure; but on the other hand it has been asserted, that they have never afforded any permanent benefit, and that they have often produced manifest harm. It appears, however, from a disinterested examination of the cases, and from the testimony of patients as well as of practitioners, that both those assertions imply a considerable degree of exaggeration. The result of this examination will be found condensed in the following paragraphs.

THE diluted hydrocarbonate is the only one, or at least the principal aerial fluid that has been successfully administered in cases of phthisis; and it has generally afforded a sensible and almost immediate relief, by abating the hectic fever, by diminishing sensibility, by promoting sleep, and by reducing the quantity of expectoration.

BUT the use of hydrocarbonate is always attended with a diminution of strength.

Hence,

Hence, when the patients are very feeble, which is generally the case in an advanced state of the disorder, the disadvantage which arises from the diminution of strength, is greater than the advantage which arises from the other good effects of the hydrocarbonate. When the patients, therefore, are too far gone, the use of the hydrocarbonate produces an apparent but not a real melioration.

IT is on the same account that this elastic fluid cannot be administered to patients, that labour under great weakness of the digestive organs. In such cases the vapour of ether is, perhaps, the only elastic fluid that may be tried with safety; and the use of it is attended with at least a temporary relief.

THERE are two or three cases of real phthisis creditably related, where a perfect cure seems to have been performed; though in a great many others the application of aerial fluids proved evidently useless. But
though

though from those few successful cases no great expectations can be derived, yet in a disease where no remedy has ever been found efficacious, surely it is not improper to try an application which at least affords a ray of hope.

THE quantity of diluted hydrocarbonate, which may be administered daily, is various, according to the constitution of the patient. It is proper, however, to begin by administering one pint of hydrocarbonate with between twenty and thirty pints of common air; and the quantity of the former may, in process of time, be increased conformably to the effects. In breathing this quantity of elastic fluid, it will be proper to let the patient rest four or five times, or in short whenever any giddiness happens to come on; for this giddiness or vertigo generally goes off in two or three minutes, after which the patient may again apply his mouth to the bag or vessel which contains the diluted hydrocarbonate.

IT

IT will be found, that custom habituates the lungs to bear the hydrocarbonate, in an increased proportion, as far as a certain limit. Thus the same patient who at first was made vertiginous by a quart of hydrocarbonate, diluted with twenty quarts of common air, will, in process of time, be hardly affected by the double of that quantity.

THE inhalation of the vapour of ether, as also of other sorts of reduced atmospheres, such as a mixture of azote and common air, of carbonic acid gas and common air, of hydrogen and common air, have been of partial use; however, the mixture last-mentioned seems to have proved more beneficial than any of the rest. This sort of reduced atmosphere must be administered more freely than the diluted hydrocarbonate. The vapour of ether may be inhaled with the utmost facility, as no apparatus is required for it, and it will be found at least of temporary use for allaying the cough, the pain, &c.

THOUGH

THOUGH the use of reduced atmospheres be more promising in cases of incipient phthisis, yet that application should not be neglected in any state of the disorder; since the elastic fluids are the only remedies which can be applied immediately to the part affected.

OF the various species of phthisis pulmonaris, two only, *viz.* the chlorotic and the syphilitic, seem to require a different treatment, and I find a few cases in which syphilitic ulcers in the lungs are said to have been cured by the use of diluted oxygen, which was breathed once a day; but this treatment was accompanied with mercurial and other medicines; which, however, when administered by themselves, had produced no good effect.

THE inhalation of carbonic acid gas is said to have proved beneficial in hectic disorders, but I do not know how far this practice may be safe or useful, as I do not find any very particular information concerning it.

Coughs.

OF the various species of cough, those which originate from catarrh and from phthisis have been already mentioned under those articles, to which the reader is referred. But with respect to the application of factitious airs to other species of cough, I do not find much authentic information, and of course must leave it for future investigation.

Debility.

AN universal debility is not unfrequently met with amongst persons of all ages, and especially among women. It is sometimes the unconquerable effect of former disorders that are subdued, or of lurking and invisible causes. Whatever its origin may be, the symptoms it produces are numerous and often of the utmost consequence. It produces paleness, emaciation, difficulty of breathing, palpitation, indigestion, loss of sleep, frequent cough, swellings of the extremities,

tremities, weakness of sight, loss of voice, suppression of the usual evacuations, &c. Those symptoms, of which a greater or less number is to be observed in the same individual, are, at first, the consequence of the debility, but they soon become the fomenters of that very languor, and consequently of each other.

WHEN the disease, which produces the languor, is present and known, I need hardly mention that the removal of that cause should be the first object of the practitioner. But when that is not the case, diluted oxygen air may be administered with great hopes of success; for such treatment has been found beneficial in a great many cases of this sort, and wonderful cures have been performed where no other remedy was found efficacious. The improvement is perceived sooner or later, according to the nature of the cases; but, generally speaking, it becomes manifest in about a fortnight or three weeks time. It operates by strengthening and improving the whole habit. The

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pulse

pulse becomes stronger, the aspect acquires colour, the lassitude after exercise goes off gradually, the appetite is improved, and the rest of the symptoms disappear gradually.

It has been repeatedly observed, that in cases of this sort the quantity of oxygen must be nicely regulated by the strength of the patient. If too small a quantity be administered, little or no improvement will be obtained ; but if the quantity be too great, the effects will be hurtful, and some of the bad symptoms are thereby increased. A few days experience will soon indicate the proper dose of oxygen. But I would recommend to begin by giving one quart of oxygen, with twelve or fifteen quarts of common, air, per day, and to increase or diminish the quantity according to circumstances. It must, however, be remembered, that when a sensible improvement becomes manifest, more advantage is to be derived from a moderate dose regularly administered, than from an increased proportion of oxygen.

I DO

I do not find that the leaving off of this application has ever been productive of any harm, but at all events it may be not improper to relinquish it by degrees, *viz.* by diminishing the quantity of oxygen, and intermitting the application by the interval of a day or two.

Digestion impaired, or Dyspepsia.

WE have not a clear account of the various species of dyspepsia to which the aerial fluids have been applied, nor indeed have they been tried in a great variety of cases. But upon the whole it appears, that when debility is the cause, and especially when it is accompanied with what is called a nervous head-ach, the inhalation of diluted oxygen air has been of singular use, and the disorder has been frequently removed in a short time.

IF the impaired digestion be accompanied with other symptoms of debility besides the head-ach, the administration of

134 MEDICINAL PROPERTIES of

oxygen may be regulated agreeably to what has been mentioned in the preceding article, otherwise a greater proportion of it may be administered, as about four or five, or six pints of it, with between twenty and thirty of common air. In cases of this sort, the good effects of the oxygen may be perceived in the course of a few days.

THIS treatment has proved peculiarly beneficial to such persons as have contracted a weakness of digestion, from having been confined in the foul air of workshops, counting-houses, &c.

I FIND, likewise, the case of a man who had been afflicted for upwards of five years with heart-burn, flatulence, lowness of spirits, and coldness of the extremities, which seemed to indicate a bad digestion, and who was perfectly cured by the inhalation of diluted oxygen, and by drinking water impregnated with carbonic acid gas, together with some salt of steel.

Dropsy.

Dropfy.

IN a variety of dropfical cafes the inhalation of diluted oxygen air has been attended with fuccefs, and this fuccefs has feveral times amounted to a complete cure. This treatment feems to be more efficacious in an incipient dropfy, and when the diforder is confined to the extremities, than in other ftates of it. Yet I find a remarkable cafe of hydrothorax which was effectually cured, though a fimilar one was not attended with the fame effect; and likewise a cafe of water in the head of a boy of thirteen years, which is faid to have been partially removed by the inhalation of diluted oxygen air.

ONE quart of oxygen, and about fifteen of common air, per day, may be fufficient for the beginning; but the proportion of oxygen muft be increafed in the courfe of three or four days (provided no bad effects enfue) to two quarts; and foon after it will

be proper to double the quantity both of oxygen and of common air.

THIS regimen must be persisted in for weeks and months, according to the nature of the case; and should any inflammatory symptoms appear in the course of this application, the inhalation of the diluted oxygen may, in that case, be suspended or moderated for two or three days.

Eruptions.

I FIND a few cases of scorbutic eruptions on the face, as also on other parts of the body, in which a complete cure was accomplished by the daily inhalation of diluted oxygen air.

IN cases of tumors and eruptions, which derive their origin from debility and a poor or thin state of the blood, the like treatment has been found beneficial.

Two or three pints of oxygen, with about ten times that quantity of common air, per day, is sufficient for the beginning; but in cases of this sort, the proportion of oxygen should not be much increased.

I NEED hardly add, that in such cases it is proper to continue the usual dressings of the parts affected, the means of keeping the body gently open, &c.

Fevers.

I DO not know whether the factitious airs have been tried with success in other sorts of fever, besides the putrid and the hectic. With respect to the latter, the reader may consult what has already been said under the articles of *chlorosis* and *consumption*. But in putrid fevers the carbonic acid gas is generally allowed to be an useful remedy; yet the use of it has not proved so generally beneficial as it was at first believed.

THIS

THIS gas is applied internally, not to the lungs but to the stomach and intestines, in three different manners, *viz.* by way of clysters, either in the aerial form or in combination with water; by way of drink when combined with water; and, lastly, by giving through the mouth such substances as contain carbonic acid gas in abundance, that is liquors in a state of fermentation, certain fruits, &c.

WHEN a large quantity of it is given either in the aerial form or in combination with water, the abdomen is frequently distended by it; for though this gas is pretty easily imbibed by animal fluids, the fluids which it usually meets with in the stomach, &c. are seldom capable of absorbing more than a moderate quantity of it. However, the distention of the abdomen is not so very detrimental, but it may be supported to a certain degree.

WHAT seems to render the carbonic acid gas not so efficacious in cases of putrid fevers,

fevers, as from its usual properties one might be led to expect, is the difficulty of its insinuation into the vascular system of the whole body. The lacteals imbibe it in small quantity, and the difficulty becomes greater in certain states of the disorder; whenever, therefore, the disease is not in a very alarming state, *viz.* so as to give time for the insinuation of the carbonic acid gas into the fluids of the body, then more benefit is to be expected from it. There are, however, some cases in record, where the free use of carbonic acid gas proved efficacious in the worst state of putrid diseases; and I do not find that it was ever attended with noxious effects.

OF the various substances which are administered in putrid diseases, on account of the carbonic acid gas which they contain, the following are the principal ones, *viz.* effervescent alkaline and acid mixtures, consisting of a solution of salt of tartar, to which lemon juice, or diluted vitriolic acid, or diluted nitrous acid, is added the mo-

ment before it is to be drank; sweetwort, or an infusion of malt, yeast, and certain acidulous fruits, such as oranges, lemons, &c.

I SHALL not attempt to define the circumstances in which one or other of those articles may be preferable, nor is it necessary to limit the doses. The circumstances of such cases being very numerous and diversified, must be left to the skill of the attending practitioners. If the carbonic acid gas be administered in the aerial form, the quantity of it can hardly be too great, provided it does not distend the abdomen too much; but if the gas be given in combination with other substances, the quantity of those other substances must be limited, not by the quantity of carbonic acid gas that may be contained in them, but by their other properties, which must be proportionate to the state of the patient.

It has been proposed (not without expectations of success, though with difficulty
of

of execution) to introduce, in certain cases, the whole body of the patient, the mouth excepted, into a vessel full of carbonic acid gas; for as this gas is absorbed by the pores of the skin, a greater quantity of it might thereby be imbibed.

Head-Ach.

THE various origin of this disorder, and the small number of cases that are circumstantially related, prevent our forming a comprehensive idea of the use of factitious airs in cases of this sort. The inhalation of diluted oxygen air, has sometimes been of use in what is commonly called nervous head-ach; and it appears that in such cases, a very great proportion of oxygen air has been administered, even as much as five or six gallons per day. I would not, however, recommend so free a use of it.

IN head-achs that arise from a weak digestion, the inhalation of diluted oxygen air is an useful remedy. See the article *Digestion*.

Hæmoptysis,

Hæmoptysis, or Spitting of Blood.

I FIND a few cases of this disorder, in which the administration of hydrocarbonate gas was administered with good effect. The account of the most remarkable one will be found in the next chapter.

Ophthalmia.

IN cases of ophthalmia, and weakness of sight, when accompanied with a relaxed habit of body, the inhalation of diluted oxygen air has been of singular use. About two quarts (when a smaller quantity has proved ineffectual) of oxygen air, with about fifteen of common air, is a dose sufficient for each day.

Phthisis Pulmonalis.

See *Consumption*.

Paralysis.

Paralysis.

I FIND a few cases of that species of paralysis which is occasioned by preparations of lead, the *colica pictonum*, where the inhalation of diluted oxygen air proved beneficial. Three or four pints of it, with about thirty pints of common air, is a dose sufficient for each day.

Scurvy.

THE use of carbonic acid gas has long been considered as a powerful remedy in scorbutic disorders; and certain it is, that when the disorder is not too far advanced, a perfect cure may be generally expected from it; and even in cases of the worst sort, the free use of this gas has frequently accomplished a perfect recovery.

ALL the various ways of administering this gas, which have been mentioned for the cure of putrid fevers (See the article *Fevers*.)

Fevers) are applicable to this sort of disorder.

SINCE much has been written concerning the scurvy, and since the methods of administering such substances as contain abundance of carbonic acid gas, are generally known and successfully administered, I shall not detain the reader with long extracts from more able writers; but shall only add, that, whilst the carbonic acid gas is applied to the stomach and intestines, a moderate dose of diluted oxygen air should be applied to the lungs by the way of respiration; for whilst the former acts as an antiseptic, and corrects the putrid tendency, the latter gives energy and vigor to the fibre, and enables the body to throw off the morbid humours with greater quickness.

Stone in the Bladder, &c.

WATER impregnated with carbonic acid gas, has been long known to afford relief in calculous complaints of the bladder
and

and urinary passage. But by the addition of a fixed alkali, the remedy has of late been rendered much more efficacious in cases of the above-mentioned sort, and even when a large stone has actually existed in the bladder. I do not know how far this *acidulous soda water*, as it is commonly called, may operate by way of a solvent of a large stone; but certain it is, that even in those cases it affords considerable relief, and it seems effectually to prevent the farther accumulation of the stony matter, by dissolving the mucus as well as the small stony concretions, and washing them off from the kidneys, ureters, bladder, &c. It is, therefore, given in all complaints that originate from a thickening of, or deposition of gross matter by, the urine in the above-mentioned parts, such as strangury, pain in voiding the urine, ulceration of the parts, &c.

For this purpose one ounce of soda is dissolved in four or five pints of rain, or of boiled soft, water; and the solution is then impregnated, as much as possible, with

L carbonic

carbonic acid gas *. Of this water, a pint a day is the quantity usually given for the above-mentioned disorders, and it is to be drank not all at once, but at three different times, *viz.* morning, noon, and night.

INDEPENDENT of those diseases, the acidulous soda water is successfully administered in scorbutic cases, bilious complaints, weakness of the digestive organs, some nervous affections, &c. but in those the proportion of the alkali, as well as the daily allowance, must be diminished according to the circumstances of the case.

Swellings.

I FIND one case only of a white swelling of the knee recorded, in which a per-

* In Dr. Nooth's glass apparatus for impregnating water with carbonic acid gas, the quantity of gas that can be thrown into it is very moderate, yet efficacious; but the soda water which is now prepared and sold in London by a Mr. Schweppe, contains an incomparably greater proportion of carbonic acid gas, and accordingly is much more efficacious.

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fect cure is said to have been accomplished by the daily inhalation of diluted oxygen air. As those swellings owe their origin in great measure to weakness of body, it is likely that the use of oxygen, which invigorates the animal fibre, may prove an useful remedy.

THE like treatment is said to have been found sometimes useful in scrophulous tumours.

Ulcers.

THE factitious airs have been frequently administered in cases of ulcers on different parts of the body, and especially on the legs; but the indiscriminate and injudicious application, which seems evident in many cases, has been productive of equivocal effects. However, a careful examination of the particular circumstances shews, in agreement with the theory, that when the ulcers originate from a poor state of the blood, and a debilitated habit, the daily

L 2 inhalation

inhalation of three or four pints of oxygen air, with about ten times that quantity of common air, is of singular use; and by this means some ulcers of the worst kind, *viz.* painful, foetid, stubborn, &c. and when they were accompanied with scurfy eruptions over great part of the body, with want of appetite, &c. have been completely cured in about six weeks time.

IN ulcers of other sort the state of the patient, as also the origin of the disorder, must be carefully attended to, and the elastic fluids, when they may be thought useful, must be administered accordingly, otherwise they will produce more harm than good. In fact, I find a case of a scrophulous ulcer, where the oxygen air proved detrimental; but a mixture of oxygen, hydrocarbonate, and common air, accomplished the cure. This case will be found in the next chapter.

IN all cases of ulcers, the external application of carbonic acid gas generally affords
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an alleviation of pain, as well as of the fœtor, and a better discharge.

CHAPTER VIII.

Medical Cases in which Aerial Fluids were administered.

A COLLECTION of medical cases, in which the factitious airs have been administered with great success, forms the content of the present chapter. Those cases have been either extracted from other publications, or they have been communicated by intelligent friends; and they have been selected out of a great number, merely for the purpose of shewing the practical methods of administering the artificial elastic fluids. Such cases, therefore, have been preferred, as by the variety of circumstances seemed more likely to manifest the modes of applying, proportioning, varying, and

L 3 suspending

150 MEDICINAL PROPERTIES *of*
suspending the administration of the factitious airs.

CONVINCED that the unskilful application of this new set of remedies has produced considerable harm, and has thrown a degree of discredit on the practice, I take the liberty of warning the practitioners against drawing hasty conclusions from a few crude, and, in all probability, ill-managed cases. For however skilled those gentlemen may be in other branches of physic, it is at least likely that in this new application their management of patients may not be generally correct; and of course the failure is not always to be attributed to the want of power in the aerial fluids.

CASE I.

Communicated by Dr. J. Lind, of Windsor.

THE first time I applied the modified atmosphere as a remedy, was in the case of an officer of the Excise, who, during the
fevere

severe weather of January, 1797, being much exposed to the cold in the exercise of his duty, had got a violent cough, which caused the rupture of a considerable blood vessel in his lungs, and this was soon followed by the symptoms of a rapid consumption. On the 25th of January he first applied to me, when I ordered him an infusion of roses, acidulated with vitriolic acid, and small doses of ipecacuanha, to stop the hæmoptoe; and for the cough and hectic fever I recommended him to breathe, several times in the course of the day, the vapour of vitriolic ether, in which the powdered leaves of *cicuta* were infused, after the manner recommended by Dr. Pearson, of Birmingham. The benefit which he received from this application was really remarkable, for after not more than four or five days, almost all the bad symptoms were wonderfully diminished; yet, finding that he got hardly any sleep at night, and that he had been a bad sleeper for above a year, I made him inhale about a quart of hydro-carbonate gas, diluted with about fourteen

quarts of common air, at bed-time, which procured him an uninterrupted night's rest, such as he had not experienced for many months before. He continued to follow the same course till the 20th of February, when his health being perfectly restored, he returned to his duty.—N. B. When he inhaled the diluted hydrocarbonate, he drew it in over the steam of hot water, with the inhaler which I have constructed on the plan of Mr. Watt's refrigeratory *.

CASE II.

Communicated by the same.

I TRIED the diluted hydrocarbonate likewise with success, in an inflammation of the lungs. The patient was a man of sixty-six years of age, labouring under an inflammation of the lungs, but attended

* This inhaler is made of japanned tin, and being filled with hot water, is interposed between the bag or receiver of air and the mouth of the patient, so that the air is heated by the vapour of hot water in passing through it.

with

with so small a pulse that bleeding did not appear adviseable. I therefore directed him to breathe the hydrocarbonate gas, diluted nearly in the proportion mentioned in the preceding case, which he did every night, and occasionally whenever the pain returned. The effect of the modified air was immediate, and very remarkable, for not only the pain was removed, but he used to say that the hydrocarbonate had deprived him of his body, and had left him only his head; such was the diminution of irritability which this gas is capable of producing.

THE disorder vanished in a very short time: for in seven days from the commencement of the application, his health was perfectly restored.

THIS case shews that in inflammations of the lungs, when the pulse is weak, which is sometimes the case, the reduced atmospheres are, perhaps, the only application practicable.

CASE III.

Related by Dr. Carmichael.

Birmingham, March, 1795.

I. B. æt. 45, was attacked about four months since with difficulty of breathing, attended at times with pain under the sternum, and commonly with a sense of tightness of the thorax, frequent cough, with copious expectoration of a tough whitish fluid, pulse 96, body regular, appetite variable. He has seldom passed four and twenty hours without a material aggravation of all his symptoms. Was first attacked with this disorder six years ago, and has regularly suffered very severely from it every winter since that period; it has always left him about the beginning of May, and he has kept free from complaint during the summer and autumn months. He has tried many remedies, but never with more than very transitory relief.

FEBRUARY 14th, 1795, I directed him to inhale daily a mixture of hydrocarbonate
and

and atmospheric air, in the proportion of 1 to 19.—15th, No sensible effects from the use of the hydrocarbonate; the strength of the mixture was therefore increased in the proportion of two to 18.—16th, No vertigo, nor any other sensible effect, produced by the use of the modified air. The proportion still farther increased to 4 to 18.—17th, Considerable vertigo produced by yesterday's dose, which returned at intervals, attended by head-ach during the day. Breathing much relieved, even during the act of inhaling the modified air, and has since continued tolerably easy. Slept better last night than he has been accustomed to do for some months.—22d, Hydrocarbonate continues to produce considerable giddiness; breathing, except some short intervals of slight return, continues much easier. Cough less frequent, expectoration much diminished. Continues to enjoy comfortable sleep.—27th, Had a considerable return of difficulty of breathing on the afternoon of the 25th, which, however, abated so much before his usual bed-time,

as not to prevent him from passing the night comfortably. Cough infrequent, and rarely attended with expectoration. Has for some time past had no pain under his sternum, and rarely any sense of tightness of his thorax. —March 4th, He is in every respect so much better, that he intends to return to his usual occupation (making moulds in a cast-iron foundry) on the 9th inst. Modified air continues to produce vertigo. —March 9th, He continued without any return of his complaint, and returned to his employment as he intended; but after working for a few hours only, he was obliged to desist, by a return of the sense of tightness on his thorax, and considerable difficulty of breathing. Breathing increased in difficulty towards evening, and still continues, attended by frequent dry cough. —13th, Continues to breathe with considerable difficulty, pulse 100; sleepless nights; cough more frequent, but now attended with considerable expectoration. —17th, Difficulty of breathing continued until yesterday; has passed a better night than usual;



usual ; and this morning finds himself much better.—20th, Breathing continues easier ; cough much less frequent, and quantity of expectoration diminished. Has slept for some nights past comfortably ; pulse 86. Modified air continues to produce considerable vertigo.—29th, Continues uniformly to recover ; his cough is very trifling, and he expectorates better ; his strength is so much improved, that he can use considerable exercise without inconvenience. Sleeps uniformly well.—He returns to his work to-morrow, but for the present is to work within doors. He is of opinion that he is in every respect equal to the undertaking.

CASE IV.

Related by the same.

J. T. æt. 40. has for two years past been affected, during the winter and spring months, with cough and expectoration, and at times with pains in his breast, accompanied with slight dyspnœa. These symptoms,

toms, in general, left him during the summer months, and never at any time arose to such a degree as to prevent him from following his usual occupation. In the beginning of October last he was seized with pain on his side, cough, dyspnœa, and after some time with copious expectoration. He applied for my advice in the beginning of November. At that time he had an almost incessant cough, attended with copious expectoration; he complained of a sense of tightness across his thorax, and much dyspnœa on the slightest exertion; his pulse was in general from 110 to 120, his nights were restless, and attended with profuse perspirations, his body was irregular, his appetite much impaired, his frame much emaciated. I ordered for him, at different times, emetics, squills, ammoniacum, blisters, &c. but from none of them did he derive more than a very temporary relief.— November 27th, he began the use of the hydrocarbonate; I directed him at first to inhale a mixture containing a quart and a half of this species of factitious air, and
nineteen

nineteen of atmospheric air. This quantity he used in about twenty minutes, breathing it for twenty seconds together, and then resting for one, two, or three minutes, according to the degree of vertigo produced.—28th, The vertigo produced by yesterday's inhalation was very severe, and returned at intervals during the evening. He has passed a much better night than usual, and says that the dyspnœa and sense of stricture on the thorax are much relieved. The quantity of hydrocarbonate diminished to one quart, diluted as above.—30th, Cough much relieved, sense of stricture gone, dyspnœa less troublesome on motion, has had better nights, and his perspirations are less profuse; pulse 106, appetite rather better.—December 7th, Cough evidently better, expectoration considerably diminished, pulse 95, body for some days past regular; breathing so much improved that he can with ease walk up stairs to his chamber and undress himself, without return of dyspnœa, which he could not before accomplish without the greatest difficulty; sleeps better than
he

he has done for months past, perspirations entirely left him, appetite mended.—15th, Continues to recover in every respect, has at times some return of tightness on his breast, but which is uniformly relieved or completely carried off by the hydrocarbonate. His countenance is evidently altered for the better, and he is of opinion that his strength returns. Notwithstanding that the modified air still continues to produce considerable vertigo, I increased the quantity to two quarts, diluted as before.—27th, Cough very much relieved, expectorated matter reduced to one-third of its former quantity, pulse from 84 to 90. He has evidently acquired flesh, and he is of opinion that his strength continues to improve.—January 6th, 1795, Cough rather more frequent, and attended with some degree of dyspnœa. On account of the severity of the weather, which evidently affects him, I ordered him not to stir from home. At this time he began to breathe the modified air, of the strength directed above, twice a day.—16th, Cough relieved, quantity of expectorated

torated matter much the same as reported on the 27th ult.; in other respects the same.—February 1st, On account of the unusual severity of the weather, no advance has been made since last report. Cough more variable, and at times attended with some degree of dyspnœa, expectorated matter increased, he does not, however, emaciate. —12th, Cough much abated, quantity of expectoration reduced to one-fifth of its former quantity, his strength is so much recruited that it is with difficulty I can restrain him from returning to his occupation. In every respect he is much better.—March 1st, continues to gain strength, cough less frequent, and expectoration still diminishing in quantity, appetite good, sleeps well. As I could not prevail with him to remain longer at home, I advised him, before he returned to his usual occupation, to walk out a little daily.

HE complied with my advice, and continued to gain ground till the 9th of that month, when in the evening he was seized

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with

with the usual symptoms of the influenza, an epidemic catarrhal infection, which at that time prevailed much in this place. The febrile symptoms ran high, and were attended by frequent cough and considerable pain on his side; he complained also of severe head-ach, and unusual langour; he was thirsty; his tongue was white, and his pulse 110.—March 15th, febrile symptoms continue; cough frequent, but now attended with increased expectoration; pain of his side less severe; considerable dyspnœa on the slightest motion; pulse 115, small and weak. Until this attack he inhaled twice daily a gallon of hydrocarbonate, diluted with four times the quantity of atmospheric air, but, as his strength wasted, it was found necessary to lessen the quantity to one quart diluted as above.—March 20th, pain of his side something easier, but his cough is increased in frequency, and his expectoration more copious. Restless nights; no appetite; strength so much impaired that, for the last four days, he has not been able to inhale the modified air; pulse 120.

I directed

I directed a warm stimulating plaister to be applied to his side, and five drops of tinctura opii to be given every four hours.—March 28th, pain of his side gone, but his other symptoms continue; bowels regular; has had better nights, but his sleep has been attended with profuse perspirations; the tinctura opii was omitted, and he was directed to take at nearly the same intervals a small glass full of port wine.—April 15th, complaints continue without material alteration. From this date he re-commenced the use of the hydrocarbonate, beginning with it of the strength of one pint to sixteen quarts of common air.—April 25th, at first the modified air occasioned considerable vertigo, but he soon became so much habituated to its operation that the quantity was increased to one, and afterwards to two, quarts. His perspirations have abated, his cough has been less urgent, the quantity of his expectoration has diminished, and the dyspnœa, with which he has for some time past been troubled on the slightest motion, is greatly alleviated.

MARCH 3, Since the last report he has experienced considerable amendment, pulse 98. The quantity of hydrocarbonate was further increased to a gallon, diluted with four times that quantity of atmospheric air. May 15th, he has continued to recover so much in every respect, that yesterday he was able to walk fourteen miles into the country.

FROM this time I did not see him till the middle of June, when he returned to this place with an intention to follow his usual occupation. He was in every particular so much better, that he seemed to have recovered his health completely. I advised him, however, to the contrary, to which he consented, and he has since been occupied in hay-making, and more lately in reaping. I saw him a few days ago; he cannot be said either to cough or expectorate, except in the morning, and then in the most trifling degree, and his strength is so completely restored, that he has been earning wages equal to those of the stoutest of his fellow-labourers,

labourers, with both ease to himself and satisfaction to his employer.

CASE V.

Related by Dr. W. Pearson.

ELIZABETH VYSE, aged 27, having been seized at the end of autumn with cough, fever, and spitting of blood, applied at the hospital for relief, and came under my care last October. She informed me she had been subject to a cough for three winters. She had a quick and small pulse, flushed cheeks, dyspnœa, pain on the side, constant cough attended with copious expectoration, and night-sweats. She was very feeble and much emaciated. The hæmoptoe was soon removed by the medicines commonly prescribed in such cases; but the symptoms continued. I therefore ordered her, on the 12th of November, to breathe the vapour of vitriolic æther, impregnated with extract of cicuta two or three times a day. On the 19th, when I saw her again, she informed me that she had obtained great

M 3 relief

relief from the æther vapour, having much less tightness across the chest, and less pain of the side. She said she was somewhat giddy after every inhalation.—December the 3d, less fever, less cough, and considerably better in every respect. Has found more benefit (to use her own words) from the æther application than from any thing else.—December 10th, cough and other complaints so slight, that she says she does not require any more medicines.

N. B. During the use of æther vapour, she took a decoction of Peruvian bark and sarsaparilla, and pills composed of extract of cicuta and rhubarb.

CASE VI.

*Related by Mr. Barr. Birmingham, October 9,
1795.*

MR. BARROR, of Barton-under-Needwood, being in this town on a visit to a friend in the spring of 1793, was seized with an highly inflammatory fever, attended
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with a violent pain of the side. This fever was followed by a dry tickling cough, a sense of tightness in breathing, much languor, and a great degree of restlessness and anxiety. His bowels felt full, tense, and uneasy; his pulse intermitted; and he complained that his urine, though nearly in the usual quantity, did not flow freely, and that he had always the sensation of not having evacuated the whole. Blisters, bolusses of triturated mercury, and a decoction first of Peruvian, and afterwards of Anguſtra, bark were prescribed. He was relieved by these medicines, but he neither recovered his strength nor his spirits. In this situation nearly he passed the remainder of the year in the country; in the spring of 1794 he came to Birmingham again, with all the symptoms of his disorder increased, particularly the oppression in breathing. He could neither lie down in bed with comfort, nor ascend the smallest activity without the greatest uneasiness. His urine was diminished in quantity, and voided with difficulty. A decoction of Seneka root, and

small doses of Digitalis were directed and continued for two or three weeks; but they rather seemed to amuse than relieve him. He called on me again last April, and told me that all medicines had lost the power of relieving him, that his breathing was now more generally difficult, that his urine was very scanty, and that his appetite was entirely gone. I prescribed the Digitalis with a bitter infusion. He went into the country and continued these medicines for some time. Towards the end of July he called upon me again—but, alas! how changed! His face was now become pale and emaciated, his eyes stared as if taking a last conscious view of their object; which last circumstance much alarmed his friends.—His legs were swelled to such a degree that the skin was become much inflamed, and in danger of bursting. He had a continual tenesmus, and made very little urine; he could not endure an horizontal posture for a moment, but was under the necessity of being bolstered upright in bed through the night; even then he slept little, and that
little

little was disturbed and unrefreshing, for he frequently started from his sleep under an impression of instant suffocation.

HAVING seen an account of the happy relief Sir William Chambers had experienced from oxygen in a similar situation, I wrote to my patient, and advised the adoption of the pneumatic plan. I did this, I confess, in the present instance, with little hope of advantage; but as the most powerful medicines had produced no salutary effect, I felt it my duty to him, as well as to the cause of humanity, to urge this compliance. I procured him a reading of the case, and the similarity of the circumstances was so striking, that he agreed to place himself immediately under my care.

HE arrived here on the 12th of August, and began to inspire the factitious air on the 13th. I directed one quart of oxygen mixed with nineteen of atmospheric air, to be inhaled every day; but as the symptoms were become extremely urgent, I thought

it right to join the use of those active medicines that I had prescribed for him before. Accordingly I directed him to take half a grain of *Digitalis* in substance, every evening, and four ounces of a decoction of *Anguſtra* bark in the course of each day. On the third night after inspiring he found himself more composed, he could remain longer in one posture, and the startings, during sleep, seemed both less frequent and less violent. Every night he was sensible of amendment; in ten days he could bear the removal of several of the pillows that bolstered him up in bed; and he could sleep for three or four hours without one starting fit. The swelling of his legs too began now to subside; the tenesmus was entirely removed; the quantity of urine was much increased, and he could walk up stairs with much ease; his appetite and cheerfulness began to return, and the pale face of disease to give place to the florid countenance of health. In the course of the second week I had gradually increased the quantity of oxygen to two quarts a day, diluted as before.

fore. In four weeks from his beginning to inspire the vital air, not a vestige of the disorder remained, except weakness; he could lay his head as low in bed as when in perfect health, and sleep the whole night; no swelling of the legs remained; no difficulty of breathing upon ordinary exertion; and every function was performed with regularity and ease. He then went home provided with a pneumatic apparatus, and directions how to use it, and laid aside the use of all medicines except a laxative pill occasionally. He passed through this town yesterday in perfect health. His strength, agility, and vivacity, are greater than in most men of his age (60).

CASE VII.

*Related by Dr. Alderson.—Hull, June 5th,
1795.*

MISS —, aged 16, had all the symptoms of approaching phthisis, cold tremors about twelve o'clock; fever, heat, and flushing
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ing every afternoon, pulse 120, countenance uncommonly florid, breathing rather difficult, cough severe, accompanied with expectoration; as several of her family had died of consumption, there could be little doubt of the tendency of these symptoms; and after finding nitre, spermaceti, vomits, &c. to have no good effect, I advised the inhalation of hydrogen air. She therefore daily inhaled a quart of pure hydrogen from water, by every now and then taking an inspiration at the mouth-piece of the tunnel. It frequently occasioned nausea and even vomiting. The pulse fell, the flushings and fever subsided, and the whole train of phthifical symptoms left her, but at the expence of her fine florid colour, her countenance having ever since been of a darker tint than before she was ill.

C A S E VIII.

*Related by Mr. Barr.—Birmingham, 14th
March 1795.*

ABOUT four months ago, a gentleman of this neighbourhood applied to me for advice in the management of a scrophulous ulcer of considerable extent. He had tried various remedies, but had derived no lasting advantage from any of them. When I first visited him he was worn down by a long course of night-watching. The deep-seated pain of the arm was so constant and severe, that it had in great measure deprived him of sleep. His countenance was pale and sickly; his limbs were continually afflicted with aching pains; every exertion, even the most gentle, seemed beyond the measure of his strength, for his body had lost much of its active power, and his mind much of its wonted energy. The discharge from the ulcer was copious, thin, bloody, and corrosive; and besides, the
whole

whole surface of the fore was so exceedingly irritable, that the mildest dressings, applied in the gentlest manner, produced very severe and lasting pain. During the first six weeks of my attendance, he regularly took as much Peruvian bark in substance as his stomach and bowels could bear; and the ulcer was dressed with various emollient, sedative, and astringent applications, but without any permanent advantage. I then recommended a trial of oxygen air, which was readily complied with. He began by inspiring four ale quarts diluted with sixteen of atmospheric air twice a day, and gradually increased the quantity of oxygen to a cubic foot and a half in the day; by pursuing this plan for about a month, his health was wonderfully improved, but the ulcer shewed no disposition to heal. The deep-seated pain was now entirely removed, but in the space of a few days more he complained of a burning sensation over the whole surface of the fore, similar to the pain arising from erysipelatous inflammation. This unpleasant sensation first commenced

menced after inspiring the whole quantity of oxygen in the space of two hours, which before had been taken in equally divided portions morning and evening. We still pursued our plan, thinking that this new pain might be owing to some accidental circumstance, and that it would soon pass away. But it every day continued to increase, and the ulcer began to spread wider and wider. The edges became thick, and were turned outwards, and the discharge became more thin and acrid.

IN this situation a local application seemed proper. I wished to have applied hydrocarbonate externally to the ulcer, but this, from some circumstance of the case, was not practicable. I then thought to moderate the stimulus of the oxygen by a mixture of hydrocarbonate, which Mr. Watt told me would occasion no chemical change in the two airs. Accordingly a mixture of three parts of oxygen, and one of hydrocarbonate, was prescribed. Four quarts of this mixed air were added to about sixteen of atmospheric,

ric,

ric, and this quantity inspired morning and evening. In less than a week the burning sensation was much diminished, and the ulcer put on a more healing appearance. The mixed air was then increased to five quarts, and used as before, which produced an increase of all the pleasant symptoms. After a few days trial of this proportion of the mixed air six quarts were prescribed. This is the quantity now inspired morning and evening.

My friend, at present, enjoys good health and a good appetite, and feels himself as strong as at any former period of his life. The ulcer is now reduced to less than half its original size, and healing rapidly. There is neither superficial nor deep-seated pain remaining, and the action of the contiguous muscles is free and easy.

CASE IX.

*Related by Dr. Redfearn, Lynn, Norfolk,
June 26, 1795.*

MR. B. F—— æt. 23, of a florid complexion, narrow chest, prominent shoulders, smooth skin, and of a delicate slender form, has been afflicted with hæmoptysis about two years and a half, attended with dyspnoea, cough, a disagreeable sense of burning in the chest, and expectoration of a purulent nature. Pulse about 100, and invariably accelerated by the hydrocarbonate air. The hectic fever was not completely formed, but he had at times a sense of chilliness in the day-time, with heat towards the evening. He began by taking one quart of hydrocarbonate, diluted with twenty-one quarts of atmospheric air, once a day. From this mixture he experienced much vertigo during its inhalation, and two hours after dinner he suddenly became vertiginous, from which, however, he soon recovered,

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although a violent head-ach remained during the rest of the evening.

THE following days he only inhaled one pint of hydrocarbonate mixed with twenty quarts of common air, once a day, which generally affected him with some slight vertigo and tightness over his forehead; the hydrocarbonate was increased gradually to two quarts or more at one dose, but I find it always necessary to begin with the original dose, where the air has been recently generated.

MY patient has been persevering in this plan about three months, and has had no return of the hæmorrhage; his cough and expectoration are very much diminished; sometimes he does not expectorate more than one table-spoonful in the space of three days; he has also never experienced any of the distressing heats in his chest, which harassed him before the administration of the air; his dyspnœa is perfectly removed; he can ride upon horseback twelve miles

miles without feeling much fatigue; his appetite is very good, and he sleeps well; pulse 80; he says he thinks his health is perfectly established.

C A S E X.

IN the month of June 1797, a lady began the use of vital air, for an entire loss of voice, which misfortune she had sustained about three years. Her constitution was extremely nervous; had been the greatest part of her life subject to deplorable spasmodic affections, particularly in the organs of respiration, on any trifling exertions of exercise, or in a confined atmosphere; she had been long habituated to an uncommon quantity of opium, to suspend the frequency and violence of her attacks, and many means had been tried in vain to diminish materially the quantity she found necessary for her support.

SHE commenced the use of the vital air under the disadvantage of remaining in

London during the summer, a circumstance which was likely to be attended with great aggravation of her complaints, being contrary to her usual practice, and, in fact, she had already begun to experience extraordinary symptoms of debility from the attempt.

ABOUT three quarts of oxygen, with twelve quarts of common air, were administered daily for about a fortnight, the effect of which was, that a slight degree of tightness about her chest came on soon after the inhalation of the air, and generally went off in five or eight minutes time; the pulse was likewise rendered fuller though not more frequent, and the nights were often attended with a sort of restlessness. In consequence of this last effect it was judged proper to diminish the quantity of oxygen air, and accordingly it was found, after repeated augmentations and diminutions of the dose, that about one quart or three pints of oxygen air, with about twelve quarts of common air, was the proportion of the
aerial

aerial fluids, which seemed to agree best with her constitution. This application was persisted in for upwards of five months, excepting some slight intermissions of a day or two occasionally, and it produced the most salutary effects. The whole habit of body began to be improved in about a month after the commencement of the application. The shortness of breath vanished gradually, as also the symptoms of debility. Her aspect became healthy, and the voice improved by slow degrees, so that by the end of October its tone was become fully equal to what it used to be previously to the illness. In short, this lady now enjoys a better state of health than she has experienced for many years.

A REMARKABLE circumstance was observed in this case with respect to the effect of opium, which is, that from long habit she had accustomed herself to take an extraordinary quantity of opium daily, in order to sustain her usual exertions of the day; for, in fact, the opium produced in her rather a

serenity of spirits than drowsiness ; but after having inhaled the oxygen air for a few days, she found that she could do with less opium, and in process of time she further observed, that the opium, instead of supporting, discomposed her so much as to oblige her to diminish the quantity of it to a very small part of what she had been accustomed to take before the use of the oxygen air.

CASE XI.

Related by Mr. Hey, in a Letter to Dr. Priestley.

January 8th, MR. LIGHTBOWNE, a young gentleman who lives with me, was seized with a fever, which, after continuing about ten days, began to be attended with those symptoms that indicate a putrescent state of the fluids.

18th. His tongue was black in the morning when I first visited him, but the
blackness

blackness went off in the day-time upon drinking; he had begun to doze much the preceding day, and now he took little notice of those that were about him; his belly was loose, and had been so for some days; his pulse beat 110 strokes in a minute, and was rather low; he was ordered to take twenty-five grains of Peruvian bark with five of tormentill-root in powder every four hours, and to use red wine and water, cold, as his common drink.

19th. I WAS called to visit him early in the morning, on account of a bleeding at the nose which had come on; he lost about eight ounces of blood, which was of a loose texture; the hæmorrhage was suppressed, though not without some difficulty, by means of tents made of soft lint dipped in cold water strongly impregnated with tincture of iron, which were introduced within the nostrils quite through to their posterior apertures, a method which has never yet failed me in like cases. His tongue was now covered with a thick black pellicle,

which was not diminished by drinking; his teeth were furred with the same kind of fordid matter, and even the roof of his mouth and fauces were not free from it; his looseness and stupor continued, and he was almost incessantly muttering to himself; he took this day a scruple of the Peruvian bark with ten grains of tormentill every two or three hours; a starch clyster, containing a drachm of the compound powder of bole, without opium, was given morning and evening; a window was set open in his room, though it was a severe frost, and the floor was frequently sprinkled with vinegar.

20th, HE continued nearly in the same state; when roused from his dozing, he generally gave a sensible answer to the questions asked him, but he immediately relapsed, and repeated his muttering. His skin was dry and harsh, but without *petechiæ*. He sometimes voided his urine and *feces* into the bed, but generally had sense enough to ask for the bed-pan. As he now
nauseated

nauseated the bark in substance, it was exchanged for Huxham's tincture, of which he took a table-spoonful every two hours in a cup full of cold water; he drank sometimes a little of the tincture of roses, but his common liquors were red wine and water, or rice-water and brandy acidulated with elixir of vitriol; before drinking he was commonly requested to rinse his mouth with water, to which a little honey and vinegar had been added. His looseness rather increased, and the stools were watery, black, and foetid; it was judged necessary to moderate this discharge, which seemed to sink him, by mixing a drachm of the *tberiacæ andromachi*, with each clyster.

21st, THE same putrid symptoms remained, and a *subfultus tendinum* came on; his stools were more foetid, and remarkably hot; the medicine and clysters were repeated.

REFLECTING upon the disagreeable necessity we seemed to lie under of confining this

this putrid matter in the intestines, lest the evacuation should destroy the *vis vitæ* before there was time to correct its bad quality, and overcome its bad effects, by the means we were using, I considered that, if this putrid ferment could be more immediately corrected, a stop would probably be put to the flux, which seemed to arise from, or at least to be increased by it, and the *fomes* of the disease would likewise be in a great measure removed: I thought nothing was so likely to effect this as the introduction of fixed air into the alimentary canal, which, from the experiments of Dr. Macbride, and those you have made since his publication, appears to be the most powerful corrector of putrefaction hitherto known. I recollected what you had recommended to me as deserving to be tried in putrid diseases; I mean the injection of this kind of air by way of clyster, and judged that in the present case such a method was clearly indicated.

THE next morning I mentioned my reflections to Dr. Hird and Dr. Crowther, who

who kindly attended this young gentleman at my request, and proposed the following method of treatment, which, with their approbation, was immediately entered upon. We first gave him five grains of ipecacuanha, to evacuate, in the most easy manner, part of the putrid *colluvies*; he was then allowed to drink freely of brisk orange-wine, which contained a good deal of fixed air, yet had not lost its sweetness. The tincture of bark was continued as before, and the water, which he drank along with it, was impregnated with fixed air from the atmosphere of a large vat of fermenting wort, in the manner I had learned from you. Instead of the astringent clyster, air alone was injected, collected from a fermenting mixture of chalk and oil of vitriol: he drank a bottle of orange-wine in the course of this day, but refused any other liquor, except water and his medicine; two bladders full of fixed air were thrown up in the afternoon.

23d, His stools were less frequent ; their heat likewise, and peculiar *fietor*, were considerably diminished ; his muttering was much abated, and the *subfultus tendinum* had left him. Finding that part of the air was rejected when given with a bladder in the usual way, I contrived a method of injecting it which was not so liable to this inconvenience. I took the flexible tube of that instrument which is used for throwing up the fume of tobacco, and tied a small bladder to the end of it that is connected with the box made for receiving the tobacco, which I had previously taken off from the tube ; I then put some bits of chalk into a six-ounce phial until it was half filled ; upon these I poured such a quantity of oil of vitriol as I thought capable of saturating the chalk, and immediately tied the bladder, which I had fixed to the tube, round the neck of the phial ; the clyster-pipe, which was fastened to the other end of the tube, was introduced into the *anus* before the oil of vitriol was poured upon the chalk. By this method the air passed gradually into
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the intestines as it was generated, the rejection of it was in a great measure prevented, and the inconvenience of keeping the patient uncovered during the operation was avoided.

24th, HE was so much better that there seemed to be no necessity for repeating the clysters; the other means were continued. The window of his room was now kept shut.

25th, ALL the symptoms of putrescency had left him; his tongue and teeth were clean; there remained no unnatural blackness or *furor* in the stools, which had now regained their proper consistence; his dozing and muttering were gone off, and the disagreeable odour of his breath and perspiration was no longer perceived. He took nourishment to-day with pleasure, and, in the afternoon, sat up an hour in his chair.

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HIS fever, however, did not immediately leave him; but this we attributed to his having caught cold from being incautiously uncovered when the window was open, and the weather extremely severe; for a cough, which had troubled him in some degree, from the beginning, increased, and he became likewise very hoarse for several days, his pulse at the same time growing quicker; but these complaints also went off, and he recovered, without any return of the bad symptoms above-mentioned.

CASE XII.

Related by Dr. Thomas Percival.

ELIZABETH GRUNDY, aged seventeen, was attacked, on the 10th of December, with the usual symptoms of a continued fever. The common method of cure was pursued, but the disease increased, and soon assumed a putrid type.

ON the 23d, I found her in a constant delirium, with a *subfultus tendinum*. Her

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skin

skin was hot and dry, her tongue black, her thirst immoderate, and stools frequent, extremely offensive, and for the most part involuntary. Her pulse beat 130 strokes in a minute; she dosed much, and was very deaf. I directed wine to be administered freely; a blister to be applied to her back; the *pediluvium* to be used several times in the day, and fixed air to be injected under the form of a clyster every two hours. The next day her stools were less frequent, had lost their fœtor, and were no longer discharged involuntarily; her pulse was reduced to 110 strokes in the minute, and her delirium was much abated. Directions were given to repeat the clysters, and to supply the patient liberally with wine. These means were assiduously pursued several days, and the young woman was so recruited by the 28th, that the injections were discontinued. She was now quite rational, and not averse to medicine. A decoction of Peruvian bark was therefore prescribed, by the use of which she speedily recovered her health.

CASE XIII.

*Communicated by an intelligent Gentleman in
the West of this Island.*

A YOUNG lady of 18, the daughter of a neighbour of mine, had been long indisposed with a sort of disorder which the medical gentlemen of the neighbourhood could neither properly define, nor in the least relieve. The origin of this indisposition is attributed to a violent cold, which this young lady caught about two years ago at a ball; for since that time she had never enjoyed her health, and, in spite of all medicines, she rather lost ground by slow degrees than shewed any appearance of amendment. The symptoms, as nearly as I can describe them, were as follows:

SHE had lost all colour from her face and hands, had a remarkably keen appetite, and eat much more than other persons of her age are wont to do; but this food gave her neither strength nor increment, and she
constantly

constantly complained of weariness, refusing to take any sort of exercise. At night she frequently had a slight fever, which terminated by the morning with an head-ach; but this fever did not come on every night, nor did it seem to follow any determinate period. She perspired profusely every night, and even in the day-time the least exertion would throw her into a profuse perspiration. She had tried bark, steel medicines, mineral waters, slight emetics, rhubarb, &c. but all in vain.

IN this state of things I first took the liberty of recommending the use of the vital air, or oxygen air, concerning which much has been said of late, and to the physical properties of which I had two years ago been witness in a course of chemical lectures, which I attended in London. After several conversations with the father of the young lady on the subject, it was at last agreed to try the oxygen air, and I undertook to perform the experiment with a few chemical vessels which I happened to have by me.

ON the tenth of April, 1797, I put eight ounces of nitre in a small and luted green glass retort, and by exposing the retort to a barely red heat, I obtained nearly two quarts measure of oxygen air, which, being mixed with about eight quarts of common air, was given to the young lady in an awkward manner; for it was introduced into an old glass receiver of an air pump, to the upper aperture of which a leathern tube was adapted, with a glass tube at the extremity of the leathern pipe, to which the patient applied her mouth, &c.

THE effect of this application was rather discouraging. The young lady felt a tightness, as she expressed it, about her head, for at least three hours after the inhalation of the vital air, and was very restless at night, in consequence of which she could not be prevailed on to repeat the inhalation for several days. At last, finding that no other bad consequence had been produced by it, she consented to make another trial, which was managed nearly in the same manner; but it

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was attended with much less tightness about her head, though with an equal degree of restlessness at night; notwithstanding which a third attempt was made on the following day, and the operation was again repeated after an interval of one day.

ALL those trials were more or less attended with the like effects as the first; yet our patient thought that, notwithstanding the restless nights which she had passed, her strength seemed to be in some measure improved, which encouraged us all to follow the application; and in order to avoid both trouble and expence as much as possible, we procured one of Mr. Watt's apparatuses from Birmingham, and some good manganese from Devonshire, with which we began to work in a large and more expeditious way.

WE found that Mr. Watt's apparatus requires a nicety of management, without which one may do more harm than good. In the first trial of this apparatus we got,

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instead of pure air, an explosive elastic fluid; for on lowering a lighted match into a bottle full of it, the air took fire and exploded. It was soon found that this inflammability was occasioned by the moisture which was contained in the manganese, in consequence of which the manganese was made very dry for the subsequent trials, and thus we obtained abundance of oxygen air, which was freed from the carbonic acid air by washing in lime water.

BEING now in possession of the proper materials, and having some expectation of success, we began, on the 22d of May, to work assiduously and regularly; and I took care to note, every three or four days, all the circumstances that seemed at all remarkable.

THREE pints of oxygen air and eight quarts of common air were administered daily, which constantly produced the tightness of the head and the restlessness at night.

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MAY the 28th, the young lady seemed to have gained strength ; but complaining much of the tightness of her head, the quantity of oxygen was diminished to one quart, with eight quarts of common air, per day, which was continued until the 10th of June, by which time her strength was unquestionably improved, and the perspiration at night was considerably diminished ; but as a cough happened to come on, we intermitted the application of the vital air for a whole week, after which, the cough having disappeared, the inhalation of the air was recommenced, and continued as before.

BY the beginning of July the good effects of our application were very considerable. The strength of the young lady was such as might be expected in a person of her time of life ; the healthy colour was in great measure returned to her face and arms ; the perspiration at night was trifling, and she seemed to acquire flesh.

ON the 15th of August, the inhalation of the diluted oxygen air was discontinued, finding that the young lady's health was completely restored.

CASE XIV.

A GENTLEMAN, 35 years of age, of a scorbutic habit, and subject to violent head-achs, was induced to try the artificial airs in December 1796, every other medical application having proved ineffectual, and his health gradually declining. He was at first advised to try the diluted oxygen air, which he accordingly did, but after three days inhalation of this air, a considerable degree of inflammation on his lungs obliged him to desist.

THE inflammation being subdued, he again inhaled the oxygen air, and a similar effect took place, though this second time the inflammation was not so considerable.

FINDING, therefore, that the oxygen air was not fit for him, he was recommended to
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drink the water impregnated with carbonic acid gas, and to take some other medicines of a demulcent kind. By following this plan for about six weeks, and by breathing the salubrious air of Devonshire, his health improved to a certain degree; the scorbutic symptoms were reduced, and the head-achs were not quite so frequent as they used to be; but after this improvement, the continuance of the above-mentioned medicines for full three months produced no other effect.

CONSIDERING that in this improved state his constitution might, perhaps, bear the stimulus of the vital air better than it had done before, he was recommended to try that air again, but to take it in smaller quantities. Accordingly he inhaled not more than one pint of it with about sixteen pints of common air every day, which, not producing any inflammation upon his lungs, he continued for upwards of two months, at the end of which time his head-achs were quite vanished, his digestion, which

had always been defective, was considerably improved, and he reckoned himself quite well.

IN the account of the preceding cases, the reader may obviously remark, that not one unsuccessful case has been introduced; on which it will be proper to mention, that in so doing I did not mean to impress the reader's mind with an exaggerated idea of the power of factitious airs; but that my only meaning was, to render him better acquainted with the practical administration of the aerial fluids, which seemed more likely to be accomplished by adducing examples, in which the practice was in some measure sanctioned by success, than otherwise.

WITH respect to the estimate of the efficacy of factitious airs in different disorders, my reader must consult the preceding chapter; for I have expressed in it the result, or what seemed to be the fair result of
all

all the cases that have come to my notice; and of such cases the few that are contained in the preceding pages form a very small part.

I WOULD not be understood to mean, that the application of the aerial fluids, in the cases of the present chapter, is to be considered as the model of practical perfection, for in some of them the administration is evidently incorrect; but they certainly give a great insight into the practice, and hope that, with the assistance of the cautions and remarks of the following chapter, they may in great measure prevent the abuse of a new set of remedies, which have all the appearance of becoming very useful tools in the hands of skilful practitioners.

CHAPTER IX.

PRACTICAL REMARKS, HINTS, &c.

Concerning the Production of Factitious Airs.

IN particular situations the difficulty of procuring proper materials and proper tools may prevent the possibility of adopting the most expeditious, or, upon the whole, the most advantageous, methods of procuring the aerial fluids; and when that is the case the practitioner must consult the first chapter of this essay, for the method which may be more suitable to the circumstances of his situation. But when there is the opportunity of procuring both materials and instruments, it is then proper to follow the plan which may appear less exceptionable.

THE cheapest article for the production of oxygen air is the mineral called *manganese*,
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nese, which is found plentifully in many parts of this island, and elsewhere. A very good sort of it is found near Exeter. It ought to be free from extraneous, and particularly noxious, minerals; but it frequently contains a considerable proportion of calcareous matter, which may be detected by powdering a little of the mineral, and pouring some nitrous acid upon the powder; for this will produce an effervescence proportionate to the quantity of calcareous matter. It must not, however, be expected to find manganese perfectly free from it; for though this may be the case with small pieces of that mineral, yet in considerably large quantities of it, such as are required for the production of oxygen air, some calcareous earth is almost always contained; but the only effect which arises from it, is the production of carbonic acid gas, together with the oxygen air, the former of which is easily separated from the latter by the well-known method of washing in lime-water.

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THE greatest quantity of oxygen air is extricated from manganese merely by the action of a full red heat; it is, therefore, necessary to put that mineral in a vessel capable of resisting the action of such a degree of heat. Earthen-ware and certain metals are the materials fit for the construction of such vessels. The former is certainly unexceptionable in point of purity; but it is not managed very easily for this purpose, and besides, the use of it is attended with considerable expence, for a vessel of that sort will hardly ever serve more than once, as on cooling after the first experiment it generally breaks; and indeed it frequently breaks in the course of the experiment. Of the metals, gold or platina vessels would be the fittest for the purpose, did not their value offer a material objection. Those metals excepted, iron is the best; for though the use of a vessel of this metal be attended with evident objections, yet, when managed with care and attention, the oxygen air may be produced of such a degree of purity as to be
more

more than sufficiently useful for medicinal purposes.

IT is necessary to remark, that in all cases, but especially when an iron vessel is used, the manganese, as well as the vessel in which it is contained, and the pipe or tube which conveys the air from it to the receiver, must be quite free from animal or vegetable matter, and perfectly dry, otherwise the elastic fluid, which is produced, may be injured in point of purity, and it may even degenerate into a noxious fluid.

WHEN those particulars are attended to, the oxygen air will principally contain a certain proportion of carbonic acid gas, and some light powder of manganese, the former of which is to be separated by means of lime, and the latter will be deposited by standing, in about ten or fourteen hours time.

THE species of inflammable gas mostly in use are extracted by means of diluted
vitriolic

vitriolic acid from zinc or iron, and by passing the steam of water over the surface of red hot zinc, or iron, or charcoal.

THE gas, extracted by means of diluted acid, holds in suspension small particles of the metals concerned, *viz.* of the zinc or the iron, the latter of which in particular may be rendered manifest by burning the gas in a bottle full of it, in which case some small particles of a dark red light will be discerned within the pale flame of the gas, which are the ferrugineous particles; for those minute red sparks are not to be seen in the inflammable gas which is obtained from pond water, or putrid matter, or, in short, from such substances as do not contain any metallic substance.

THE gas obtained by passing the steam of water over red hot zinc, holds in suspension a considerable quantity of the flowers of zinc, which it deposits in about a day's time.

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THE gas obtained in a similar manner from iron is the most abundant, and of course the cheapest.

FOR the production of the heavy inflammable gas, or hydrocarbonate, Mr. Watt recommends to use “charcoal made of the “twigs of softer woods, such as willow, “poplar, hazle, birch, or sycamore, avoiding such as have resinous or astringent “juices. Prepare the charcoal by heating it “to full ignition in an open fire, and “quenching it in clean water, or by filling “a crucible with it, covering it with clean “sand, and exposing it to a strong heat in “an air furnace, and then suffering it to “cool. In either of these cases it will be “found free from any bituminous matter, “which might contaminate the air, as generally happens with common charcoal.”

MR. WATT likewise mentions, amongst other sorts of inflammable gas, that which is extracted from a mixture of charcoal powder and flaked lime, which, on account

count of its peculiar properties seems likely to prove very useful: “In respect, *says he*, “to the medicinal properties, all I know is, “that the inflammable air from charcoal “and lime contained no fixed air separable “by washing with quick lime and water, “and that it did not cause vertigo when in-
“haled pure.”

ONE or other of those species of inflammable gas may be preferred in particular cases, and it is not only likely, but in great measure proved by actual experiment, that the particles of iron, or other matter, which are suspended in a particular sort of gas, may be peculiarly useful in certain diseases.

IN the production of inflammable gas, the introduction of any extraneous matter, and especially of vegetable or animal substances, and of minerals that contain acids, should be carefully guarded against. It is likewise advisable, for a very obvious reason, not to conduct this process by candle light.

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THE carbonic acid gas may be extracted from chalk in Mr. Watt's apparatus, according to the directions given with the said apparatus; but when no extraordinary large quantity of it is required, it is far more commodious to extract it from chalk or marble powder, and diluted vitriolic acid, in a glass vessel. The difference between chalk and marble in this respect is, that the former gives out the gas quicker, but is soon exhausted; whereas the latter gives it out more gradually, and for a greater length of time; hence, in some cases, the former, and in others the latter, may be preferred.

Concerning the Preservation of Aerial Fluids.

OXYGEN Air is not contaminated by keeping in glass receivers, or in such vessels as do not communicate any thing to it, nor does the contact of pure water injure it; but in wooden vessels, or vessels painted with oil paint, and when a considerable quantity of common river water is in con-

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tact with it, the oxygen air will be contaminated more or less.

THE various species of inflammable gas are apt to degenerate in process of time, especially if they be kept mixed with common or with oxygen air. The hydrocarbonate, in particular, is vastly more powerful when fresh made, than two or three days after. Due allowance, therefore, must be made for the loss of power in the administration of those airs.

WHEN oxygen air, or inflammable gas, is to be taken out of an air-holder or bottle, &c. by putting water in the vessel after the usual manner, it is advisable to use lime-water; for the lime will not only absorb any carbonic acid gas that may be mixed with those airs, but will also prevent the putrefaction of the water.

FOR this purpose there is no occasion to filtrate the lime-water, as is practised in the usual manner of preparing it; but it will
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be sufficient to mix the quick lime with the water, and after leaving it at rest for an hour or two, to separate the fluid and useful part from the sediment, by decanting it gently.

THE carbonic acid gas is not contaminated by keeping; but as it is absorbed by most fluids, it should not be kept in contact with much water. In most cases it will be better to produce it afresh every time it is wanted.

IN order to manage the aerial fluids with the greatest propriety, the practitioner should make himself acquainted with the modes of ascertaining their purity. This may, in great measure, be derived from what has been mentioned towards the beginning of this essay; but if a more particular description of those methods be required, and especially concerning the use of the nitrous-gas eudiometer, or phosphoric eudiometer, the reader must consult those books which have been written expressly

on the subject of aerial fluids, as the addition of those methods would increase the bulk of this essay beyond its prescribed limits.

*Concerning the Administration of Factitious
Airs.*

WHEN oil-silk bags or bladders are used, the air or mixture of airs should be introduced immediately before it is to be inhaled, in order to avoid the airs acquiring an unpleasant flavour.

THE oil-silk bags, when not actually in use, should be hung up by means of a string, which may be fastened to the pipe, or they may be put over the back of a chair; but they must not be folded or pressed.

IN the usual way of making the mixture of airs, the factitious gas, in any required quantity, is first introduced in the bag, after which the common air is forced in by means of a common pair of bellows, until the bag

is quite inflated ; for when the capacity of the bag is once known, one may easily determine the quantity of oxygen or other factitious air, which may be required in order to form a mixture in any given proportion.

WHEN common bellows are used for this purpose, care should be had that they be made free from dust and ashes, which are generally contained in such bellows as are used for common fire-places.

WHEN a person is inhaling any species of inflammable gas, or the vapour of ether, the operation should be conducted at a distance from a candle, lest the gas should catch fire, and at least occasion a surprise.

THE question, which is frequently asked, whether a patient must be confined to his house, or to any particular diet, whilst he is under a course of aerial application, suggests the propriety of observing, that there is no particular confinement or diet required merely on that account.

WHEN aerial fluids are administered, it is proper to feel the patient's pulse both before and after the inhalation, at least for the three or four first inhalations, as thereby one may, in great measure, be informed of the effect which the aerial fluid is likely to produce, and may regulate the subsequent applications accordingly.

THE patient should be enjoined to breathe the mixture of aerial fluids in an easy and natural way, and not in a forced manner, as some are apt to do.

WITH some persons the sensibility of the lungs is so very great, that they are affected with the sensation of preternatural heat, and even of inflammation, by a remarkable small quantity of oxygen; half a pint of it, mixed with about twenty times that quantity of common air, has been known to produce such an effect; and this observation has been made where there was not the least appearance of mistake, or of any equivocal circumstance. This is particularly the case
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with persons that have recently recovered from an inflammation of the lungs. In such cases, therefore, the practitioner ought to be particularly careful, and he ought to begin by administering very small quantities of oxygen.

THE above-mentioned sensation of heat generally comes on immediately after the inhalation, but sometimes it comes on some hours after, and especially in bed. It is, therefore, necessary to enquire whether any particular effect has been observed at any time between one inhalation and the next, in order to form a proper estimate of the effect of the application.

WHEN this sensation of heat or restlessness is in a trifling degree, the daily inhalation may be continued; but it must be suspended, or at least moderated, whenever it be found to increase by daily repetition.

WHAT has been observed with respect to the effect of oxygen air, may, with pro-

per and obvious changes, be also applied to the inhalation of other aerial fluids, and particularly of the hydrocarbonate.

HOWEVER strange and unaccountable some of these effects may appear, as that produced by a very small quantity of an aerial fluid in certain circumstances; or that of the preternatural heat coming on so long after the inhalation, &c. my reader may rest assured that the facts are true; and though we cannot reconcile the phænomena with the theory, yet as long as absurdity does not intervene, we must not deviate from the path which is pointed out by experience, because we are unable to understand the real causes of the effects.

A P P E N D I X.

On the Nature of Blood.

THE intimate connexion between respiration and the state of the blood, the necessary dependance of animal life on the oxygen part of the atmosphere through the intermediation of that fluid, and the various discordant opinions which have been entertained concerning the nature of blood; will easily excuse the introduction of this concise account of the nature of that fluid in the present work, whose principal object is the investigation of the action of aerial fluids on the human body.

THE name of blood has been used in a more or less extended sense by different writers.

writers. Some confine it to the red fluid, which circulates through the veins and the arteries of the animal body; others have, with propriety, extended it to that fluid, which, whether coloured or colourless, is the most abundant in the animal body, and upon the circulation of which the life of the animal principally depends; hence the red colour is not an absolute characteristic of blood; and, in fact, the blood of certain animals has not the least tint of red. Lastly, the name of blood has been bestowed even upon the fluid which circulates through the vessels of plants.

IN the following pages we shall extend our observations not farther than the red blood, and hardly beyond that of the human species; confining ourselves principally to the account of facts that are independent on particular opinions.

THIS fluid, so essentially necessary to animal life, has been examined with all the
ingenuity

ingenuity of man in a mechanical and physiological sense, as it circulates through the vessels of the body ; it has been carefully viewed, under a variety of circumstances, through the most powerful microscopes, and it has been analyzed by the most ingenious chemists. By this means many discoveries have been made, and many doubts have been cleared relatively to it ; but after all we can form a very inadequate idea of its extensive use and properties. We must, however, remain satisfied with the present knowledge of facts, and must leave the farther investigation of the subject to the labours and fortune of future observers.

BLOOD is a fluid consisting of a great variety of ingredients, some of which are always to be found in it ; whilst others are adventitious, or are to be observed in it in particular circumstances ; but the proportion of them all is not only various in different ages, and sexes, and states of the body, but is not the same even in the different
parts

parts of the same body *. A difference not so great with respect to the number, as with respect to the proportion, of the ingredients, has been observed between the blood of man, and that of other animals, such as the ox, the horse, the sheep, the hog, &c. †.

LEAVING it to the physiologists to explain how the blood circulates through the sanguiferous vessels, how the chyle is mixed with it, how a variety of fluids are secreted from it, &c. we shall examine its nature as a fluid out of the body.

BLOOD is of a uniform rich red colour, which inclines towards the florid vermilion

* Fourcroy found the blood of a human foetus to differ in three remarkable particulars from that of an adult; viz. it contains no fibrous substance, strictly speaking, but a sort of gelatinous matter; it does not take a bright colour from the contact of air; and it does not afford any marks of its containing phosphoric acid. The colour of blood is paler and thinner in infants, in women, and in phlegmatic persons, than in men of a healthy and robust constitution.

† Rouelle's Analysis.

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in blood that comes out of the arteries, and to the dark purple in blood that comes out of the veins, but the latter, as has been observed in the preceding pages, becomes brighter by exposure to respirable air. It is not so fluid as water, it feels unctuous or saponaceous to the touch, and has a little sweetish or saline taste.

Soon after its extraction from the body, as the blood cools and remains at rest, a spontaneous decomposition, or separation, of parts takes place. A thick lump of coagulated red matter is formed in the middle, called the *crassamentum*, or *clot of blood*, and a fluid of a slight greenish yellow colour surrounds it, which is called the *serum*. The quantity of serum thus formed is less at first, than a few days after; for as the coagulable part contracts and grows harder, so more and more serum is forced out of it.

By washing the lump of coagulated matter, the colouring substance is entirely separated from it, and the remainder is an insipid,

lipid, tenacious, white, and fibrous, substance. The latter is called the *coagulable lymph*, or *fibrous matter*, of the blood. The former, or coloured portion, when viewed through the microscope, is found to consist entirely of separate particles, circular and pretty uniform in their shape ; whereas the serum and the coagulable lymph, when examined with the best microscopes, do not appear to contain any distinct particles in their composition.

THE blood, therefore, consists of, or is first of all resolvable into, three distinct parts ; namely, the *serum*, the *coagulable lymph*, and the *red particles* ; each of which is likewise a compound substance, but whose components cannot be so easily separated from each other.

THE specific gravity of human blood is variable, but it always exceeds that of water ; the latter being to the former, at the least as one to 1,04, and at the most as one to 1,063. Each of its three principal components

components is likewise heavier than water; but with respect to each other, the red particles are the heaviest, and the serum is the lightest.

THE serum remains fluid in the usual temperature of the atmosphere, as far down as a few degrees below the freezing point. But it coagulates in a degree of heat about equal to 160° of Fahrenheit's thermometer. The coagulation of serum by heat is attended with two peculiar circumstances, *viz.* 1st, a considerable quantity of air is extricated from it in the act of congelation; and, 2^{dly}, a small part of it does not coagulate, but remains fluid.

THE coagulable lymph has been justly considered as the most important part of the blood, and as being the substance, from which all the other parts of the animal body derive their increment and their support. The fibrous and tenacious nature of this part, which the blood seems to derive from the gluten of our food, is so remarkable
that

that it may be stretched out to a considerable length, and by the continuance of a moderate degree of heat, it may be rendered gradually more and more consistent; so that at last it may be brought to equal the consistency of horn and even of bone.

THE red particles, from which the whole mass of blood derives its colour, seem to have no particular attraction for each other, nor for the other two components, so that in the coagulum they are only entangled and detained by the viscid part. Their peculiar and uniform shape has attracted the attention of philosophers since the latter end of the last century, about which time they were first discovered. They have been attentively examined with the best microscopes, and the appearances which have been partly observed and partly supposed, have given origin to a variety of conjectures and hypotheses, generally fanciful, and often absurd.

WHEN any thin and semitransparent part of a living animal, such as the tale of
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a small fish, the membrane which is between the toes of a frog, &c. is viewed through a good microscope; the circulation of the blood through its sanguiferous vessels, is rendered manifest only by the motion of the red particles, which follow each other at a greater or less distance; though in general each particle seems to touch, or, at least, almost to touch the following particle. They never run into each other and incorporate; and though not very hard, they are however possessed of a certain degree of consistency and elasticity; for in passing through small vessels they are frequently seen to assume an elliptical shape, and from other smaller vessels they are absolutely excluded.

THOSE particles lose their shape, and are dissolved in certain fluids. They are not dissolved in the serous part of the blood, nor in urine, except when they are left in those fluids for some days, or when those fluids are diluted with water. But water is a

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vent of those particles ; yet water may be deprived of this property by the addition of common salt, or nitre, or of almost any other neutral salt, as also by the admixture of a very small proportion of vitriolic acid.

MARINE acid much diluted with water, does not dissolve those particles, but it deprives them of their colour.

VINEGAR is likewise a solvent of the red particles, though not so powerful as water.

WHEN those particles have been once dried or dissolved in water, they cannot, by any known method, be made to reassume their former shape ; and indeed even their formation in the animal body seems to be difficultly accomplished, at least much less expeditiously than that of the other components of blood ; for in persons that have lost much blood, the sanguiferous vessels are indeed speedily filled with new blood ; but this blood continues thin and pale for
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a considerable time, and if examined through the microscope, few red particles will be found in it.

UNWILLING to interrupt the account of the chemical properties of blood, I shall reserve the farther examination of the shape and size of its red particles for the latter part of this appendix, and shall now subjoin the farther analysis of this fluid, which is principally extracted from Fourcroy's late chemical works.

BLOOD, exposed to a gentle and continued heat, passes into the state of putrid fermentation. When distilled on a water bath, it affords a phlegm of a faint smell, which is neither acid nor alkaline, but easily putrifies, in consequence of its containing an animal substance dissolved through it. Exposed to a more intense heat, blood gradually coagulates and becomes dry; it then loses seven-eighths of its weight, and becomes capable of effervescing with acids. Deficcated blood, exposed to the open

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air, attracts from it some degree of moisture, and, in the course of a few months, there is formed on it a saline efflorescence, which Rouelle has determined to be carbonate of soda. When distilled by naked fire, it affords a saline phlegm; that is, a phlegm holding in solution an ammoniacal salt, supersaturated with ammoniac. After this phlegm, a light oil passes, then a ponderous coloured oil, and ammoniacal carbonate contaminated with a thick oil. There remains in the retort a spongy coal, very difficult to be incinerated, which is found to contain muriate of soda, carbonate of soda, oxyde of iron, and a matter apparently earthy, which seems to be calcareous phosphate.

BLOOD, when burnt in a crucible, affords several products, in the following order:
 1. water, and a little ammoniac; 2. oil, and carbonate of ammoniac, which forms a yellowish vapour, thicker than the former;
 3. Prussic acid, which is easily distinguished by its foetid smell of peach-flowers; 4. phosphoric

phoric acid, which is formed by the combustion of phosphorus, and is not disengaged till the blood be reduced to a coal; 5. carbonate of soda, which is volatilized at an intense heat; 6. after this there remains in the crucible only a blackish, granulated, crystallized oxyde of iron, mixed with calcareous phosphate. The ferrugineous particles of this last product may be separated by the magnet, especially when the residuum has been previously heated together with charcoal-powder in a covered crucible.

BLOOD combined with alkalis, without previous decomposition, becomes more fluid by standing. Acids instantaneously coagulate it, and alter its colour. By filtrating this substance, evaporating the liquor passed through the filter, drying it before a moderate fire, and lixiviating the matter that has been dried, neutral salts are obtained, consisting of soda, with the acid that was mixed with the blood.

IF entire blood, mixed with a fourth part of its weight of water, be coagulated by heat, and if a part of the fluid that swims above the coagulated portion be evaporated, a substance of a brown yellow is obtained, which is easily distinguished to be true bile.

THE serum, which has been lately called the *albuminous fluid*, communicates a green tinge to syrup of violets. By distillation on a water-bath, it affords a phlegm of a mild insipid taste, which is neither acid nor alkaline, but speedily putrifies. After losing this phlegm, it is dry, hard, and transparent like horn: it is no longer soluble in water: by distillation in a retort, it affords an alkaline phlegm, a considerable quantity of ammoniacal carbonate, and a very fœtid thick oil. All these products, in general, have a peculiar fœtid smell. The coal of the serum, when distilled by naked fire, almost entirely fills the retort. It is so difficult to incinerate, that it must be kept burning for several hours, and exposed to a
great

great deal of fresh air, before it can be reduced to ashes. The ashes are of a blackish grey colour, and contain muriate and carbonate of soda, with calcareous phosphate.

THE serum, if exposed for some time to an hot temperature in an open vessel, passes readily into a state of putrefaction, and then affords a considerable quantity of ammoniacal carbonate, with an oil, the smell of which is insufferably nauseous.

THIS liquor combines with water in any proportion, and then it loses its consistency, its taste, its greenish colour. When poured into boiling water, coagulates, almost wholly, instantaneously. A portion of this fluid forms, with the water, a sort of opaque and milky white liquor; which, according to Bucquet, possesses all the characteristic properties of milk, *viz.* it is rarified, and caused to mount up, by heat, and is coagulated by the same agents, *viz.* by acids, and by alcohol.

THE serum possesses the property of fixing and rendering solid by heat, two or three times its weight of water. But when the water exceeds seven times the quantity of serum, then no coagulation takes place.

ALKALIES render the serum more fluid, and acids coagulate it. This last mixture, filtrated and evaporated after filtration, affords a neutral salt formed of soda and the acid employed; which shews that soda exists in the serum in a naked state, in full possession of all its properties. The coagulum formed in this liquor by the addition of an acid, is very speedily dissolved in ammoniac, which is the general solvent of the albuminous part of the blood; but it is not dissoluble at all in pure water. Acids precipitate this matter in union with ammoniac. The coagulum affords, by distillation, the same products as the serum deficcated, and its carbonaceous residue contains a good deal of carbonate of soda.

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THE serum, inspissated, affords azotic gas by the action of the nitric acid, with the help of a moderate heat. On increasing the fire, there is a quantity of nitrous gas disengaged from the mixture.

THE serum does not decompose calcareous or aluminous neutral salts; but it acts with sufficient energy in decomposing metallic salts.

THIS fluid is liable to be congealed by alcohol; but this coagulum differs from that formed by means of acids, chiefly for its solubility in water.

THE serum, therefore, appears to be an animal mucilage, consisting of water, acidifiable oily bases, muriate and carbonate of soda, with calcareous phosphate.

THE clot of the blood affords, by exposure to the heat of a water-bath, an insipid water; it becomes, at the same time, dry and brittle. It affords, in the retort, an alkaline

kaline phlegm, a thick oil, of a fœtid, empyreumatic smell, and a good deal of ammoniacal carbonate. The residuum which it leaves, is a spongy coal, of a sparkling metallic aspect, difficult to incinerate, and affording, when treated with sulphuric acid, sulphate of soda and sulphate of iron; there remains, after these operations, a mixture of calcareous phosphate with carbonaceous matter. When exposed to a hot atmosphere, the clot of blood readily putrifies.

WHEN the clot is divided, by washing, into its two principal components, *viz.* the red part which is dissolved in the water, and the coagulable lymph; if the former be treated with different menstrua it will be found possessed of the same characteristics with the serum; excepting that it contains a greater proportion of iron. The latter, after being well washed, will remain white, colourless, and insipid. It affords, by distillation on a water-bath, an insipid phlegm, without smell, and liable to putrefaction. Even the gentlest heat hardens this fibrous matter

matter in a singular manner. When exposed suddenly to a strong fire it shrinks like parchment. By distillation, in a retort, it affords an ammoniacal phlegm, a ponderous oil, which is thick and very foetid, and a good deal of ammoniacal carbonate, contaminated with a portion of oil. The residual coal is not very bulky, but compact, ponderous, and easier incinerated than that of the serum. Its ashes are very white; it contains no saline matter, as it must have lost, by the washing, whatever is contained of that kind; and no iron; it is a sort of residue of an earthy appearance, and seemingly calcareous phosphate.

THE fibrous part of the blood putrifies very quickly and easily. When exposed to a hot moist atmosphere, it swells, and affords a good deal of ammoniac. It is not soluble in water; when boiled in that fluid, it becomes hard, and acquires a grey colour. Alkalies do not dissolve it, but even the weakest acids combine with it. The nitric acid disengages from it a considerable quantity

quantity of azotic gas, and of Prussic acid, which comes out in vapour, and at length dissolves it with effervescence, and the disengagement of nitrous gas. When it ceases to emit nitrous gas, the residue is observed to contain oily and saline flakes, swimming in a yellowish liquor: this liquor affords, by evaporation, oxalic acid in crystals; and at the same time, deposits no inconsiderable quantity of flakes, composed of a peculiar oil, and calcareous phosphate. It appears, that hydrogen, carbon, and azote, which constitute the fibrous substance, are separated in different proportions, to combine with the oxygen of the nitric acid, and thus form the Prussic and carbonic acids that are disengaged in gas, and the oxalic and malic acids, that remain in solution, and are separated only by crystallization.

THE fibrous matter dissolves also in the muriatic acid, which converts it into a sort of green jelly. The acid of vinegar dissolves it with the help of heat: water, and especially alkalies, precipitate this fibrous
matter

matter from acids. This animal matter is decomposed in these combinations; and when separated, by whatever means, from acids, no longer exhibits the same properties.

THUS much may suffice with respect to the chemical properties of blood. I shall now return to the examination of the configuration of its red particles, with which I shall conclude this essay.

THE red particles, which form a very small part of the human blood, were discovered by means of the microscope, towards the end of the last century. They were found to be circular and uniform; a transparent flat surface appearing to be surrounded by a dark circumference. This peculiar shape seemed to indicate their being of singular use to the animal œconomy, and excited the industry of philosophers to the further investigations of their structure. As this could only be obtained without using more perfect microscopes, and as the perfection of microscopes depended

on the construction of small lenses, various methods were contrived for the attainment of this object, and microscopical lenses of very short focuses, and of course of great magnifying power, were soon produced; but the utmost power of those lenses could only discover that when the particles of blood were magnified beyond a certain number of times, they exhibited a dark speck in their middle, as a center to their circumference.

THIS is all that could be clearly discerned in those particles by means of ground lenses; but a vast deal more was suggested by the imagination; and it is curious to observe how much the eye and the understanding were deceived by the natural imperfection of the instruments, and by the influence of premature theories.

FINDING that the improvement of ground lenses, beyond the abovementioned power, was obstructed by weighty practical difficulties, the deficiency was attempted to be
supplied

supplied by the use of globules of glass made by melting ; for in the state of fusion, the natural attraction between its particles, will easily form the glass into a spherical body. Several methods were accordingly devised for constructing those globules, as may be seen in Dr. Smith's Optics, and other publications ; but those methods are either defective or absolutely impracticable. And, in fact, I do not find that any globules of very great magnifying power, were used before the time of *Father della Torre*, who, about the middle of the present century, constructed globules of wonderful minuteness, and at the same time clear and distinct.

THIS Neapolitan Friar, who, without much scientific knowledge, possessed a considerable share of ingenuity, made many observations with those magnifiers, which he published, together with a minute and faithful account of his method of constructing the glass globules, in a pamphlet, about 30 years ago. But both the construction
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of those globules, and their use as magnifiers, are very difficult ; so that few persons have attempted to repeat Torre's experiments, and amongst those, fewer still have been successful. This want of success has thrown a considerable degree of suspicion on Torre's observations ; and as few people are liberal enough to acknowledge their want of sufficient patience and address, the failure of the attempts has generally induced people to consider Torre's assertions in the light of mistakes or exaggerations. " The
 " Abbé Torre," *says a recent writer*, " examined the red particles of blood with
 " simple lenses too ; but they magnified so
 " highly, that from this cause all his noisy
 " mistake has arisen ; for he used not ground
 " lenses, but small sphericles of glass, formed by dropping melted glass into water :
 " they magnified so much that to him the
 " central spot appeared much darker ; he
 " said that these were not globules, but
 " rings. He sent his sphericles of glass,
 " and his observations from Italy, his own
 " country, to the Royal Society ; and for a
 " long

“ long while, though nobody could see
“ them, still the public were annoyed by
“ Abbé Torre’s rings *.”

SOME years ago, when Torre’s publication first became known to me, I endeavoured to construct microscopical globules after his method, and to repeat his observations. The undertaking, which at first sight appeared clear and easy, proved on trial very difficult and laborious; however, after persevering for a considerable time, I at last procured three or four useful globules out of a vast number of imperfect ones. With these globules, and an apparatus made expressly for such delicate experiments, I repeated several of Torre’s observations, and (as far as I now recollect, for both the globules and the journal of observations have been long since lost) I found that his description of appearances is very accurate, though his conjectures may sometimes be crude or mistaken.

* Bell’s Anatomy, vol. ii. p. 89.

BEING lately intent on the subject of the present work, I was desirous to repeat the above-mentioned microscopical observations, and for this purpose I obtained, after a considerable expenditure of time and labour, a few glass globules, sufficiently useful, and with them I made the observations which I shall now lay before the public. But it will be proper to premise a concise account of the principal opinions that have been entertained by various ingenious persons, concerning the construction of the red particles, as the origin of some of those opinions will be evidently pointed out by the observations that follow.

LEEUWENHOECK thought that each red particle of the blood consisted of, and was resolvable into, six smaller globules, and that every one of these secondary globules consisted of other smaller particles. Hewson took them for bladders which contained a nucleus or central body that seemed to roll from one side of the bag to the other.

-Torre

Torre saw them like rings; *viz.* consisting of an internal and an external circle, and this ring appeared to be divided, or to consist of parts joined together like the rim of a common coach wheel. Falconer considered them as flat or spheroidical bodies; for he thought he sometimes saw them sideways. “The red globules,” *says the late Mr. J. Hunter*, “are always nearly of the same size in the same animal, and when in the serum do not run into one another as oil does when divided into small globules in water. This form, therefore, does not arise simply from their not uniting with the serum, but they have really a determined shape and size. This is similar to what is observed of the globules in milk; for milk being oily, its globules are not soluble in water; neither do they consist of such pure oil as to run into each other; nor will they dissolve in oil. I suspect, therefore, that they are regular bodies, so that two of them could not unite and form one *.” Dr. Wells is of

* Treatise on the Blood, p. 41.

opinion, that the red globules consist of two parts, one within the other, and that the outer, being insoluble in serum or dilute solutions of neutral salts, defends the inner from the action of those fluids *.

MUCH having been said against the use of microscopical glass globules, especially by persons who had never seen them, I thought it necessary to ascertain the limits of the supposed distortion of the image, and other imperfections that had been attributed to them, and for this purpose I viewed certain objects of simple or determinate figures through lenses and globules of different powers, increasing gradually from a magnifying power of about eight or ten as far as that of about 400 times in lineal extension.

A DELICATE straight line made by means of a diamond on a piece of glass, and which was quite invisible to the naked

* Phil. Trans. P. II. for 1797.

eye, when thus gradually magnified, appeared always straight, provided it was made to pass through the axis of the lens or globule. The feathers of a butterfly, or rather any particular part of one of those feathers, never changed its figure though magnified upwards of 400 times.

THERE is an evident distortion of the image when the object is viewed through the edge of the lens, and especially of a globule; but no person versed in such experiments will ever observe through the edge of lenses, though the lenses be ever so perfect.

WHEN the object is not very flat, it is then evident that a perfect view of it can not be had at once; for if one part of it be in the focus, the rest of the object must of course be out of it; yet by alternately bringing one part of the object and then another to the focus, one may, in most cases, acquire a sufficiently accurate idea of its shape.

VARIOUS observations of this sort gave me reason to conclude that the glass globules are by no means so imperfect as they have been represented. Their distortion of the image is trifling and limited ; the transparency of some of them (and such only should be used) is equal to that of the best polished lenses ; but the use of those globules is very difficult, and it is on account of this difficulty that they have been neglected and misrepresented.

FOR the sake of those who may be willing to repeat such experiments, I shall barely mention the principal difficulties which attend the use of the globules.

THEIR focus is considerably nearer the surface than that of a lens of the same magnifying power ; and as a globule, in order to magnify more than the usual microscopical lenses, must be less than the 30th of an inch in diameter, and its focus shorter than the hundredth part of an inch, it follows that the common microscopical apparatuses
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are in general inapplicable to such globules, since the deviation of one or two thousandth parts of an inch in the adjustment of the focus will occasion a considerable degree of indistinction.

IT is for the same reason, that the globule must be set so as to have part of its surface actually out of the brass cell, and yet it must be secured so as not to drop out.

THE brass cell must admit of the globule being easily taken out and replaced; for when they are obscured by dust, &c. to which they are very subject, they can seldom be cleaned without removing them from the cell.—Let us now return to the particles of blood.

I HAVE repeatedly measured the diameters of the red particles, both by means of my mother-of-pearl micrometer in a compound microscope, and likewise by looking at them with one eye through a single

lens, and referring their image to a scale properly divided, and viewed with the other eye out of the microscope.

IN persons of nearly the same age the mean size of the particles differs very little indeed. In the same person they differ a little, and their figure is not very circular. This deviation from the circle is not such as a flat circular surface would assume in its different inclinations to the axis of vision; for, according to the rules of orthographic projection, the flat circular surface must appear either circular, or elliptical, or as a straight line; whereas I never saw the particles of blood as straight lines, *viz.* edgewise, and the elliptical figure, which they sometimes assume, is by no means regular.

IN an adult of the human species, the diameters of the red particles run from about 0,0003 to about 0,0004 parts of an inch, and I very seldom saw one smaller or larger than those limits. If, therefore, we
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take the smallest particles and set them in a row, we shall find that about 3334 of them will equal one inch, and if we take the largest, about 2500 of them will measure one inch.

WHEN the particles are magnified more than 40 or 50 times, and less than 80 (meaning always in diameter), they appear like colourless transparent spots inclosed within dark circles.

WHEN magnified more than 80 times, and less than about 160, a dark spot, like a dot made with ink on paper, appears in the middle of each particle.

IF the reflector which illumines the particles, instead of being situated straight before the object, be set on one side of the axis of vision, so as to throw the light obliquely on the object, then the half of the dark circle of each particle disappears, *viz.* that half which is on the side opposite to the reflector.

reflector. The central spot does at the same time appear to change its place.

WHEN the particles are magnified above 200 times, the central spot appears converted into a circle inclosing a transparent space. The diameter of this inner circle is about the half of that of the external one ; but the proportion of these diameters, or the size of the internal circle, may be caused to increase or decrease by the least alteration of the distance between the object and the microscopical lens ; and by the same means the space within the inner circle may be rendered clearer or darker than that between the two circles. The position of the inner circle is changed by the direction of the light ; for if the particle of blood be viewed through a microscopical globule, directly facing the flame of a candle, without the intermediation of any lens or reflector, the inner circle will appear concentric with the outer one ; but if the candle be moved a little to one side, so that the light may fall obliquely on the particle
of

of blood, then the inner circle will be observed to move towards the opposite side, and to acquire an elliptical shape.

WHEN the particles of blood are magnified above 400 times, an imperfect image of the candle, which is placed before the microscope, may be seen within the inner circle of each particle.

THROUGH a glass globule of 0,018 of an inch in diameter, I have seen the red particles of blood magnified about 900 times, in which case the image of the flame of the candle could be seen within the inner circle of each particle very clearly, at least so as to shew to which side the motion of the air in the room inclined it.

NOTWITHSTANDING this great magnifying power, the annulus or space between the two circles did not appear to be divided, excepting some accidental fractures, which now and then could be seen in a few of the particles.

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THESE observations seem to prove, that the red particles of blood are not perforated, but that they are globular, and of some uniform substance much less transparent than glass. They likewise shew that Mr. Hewson's idea of their containing a central body or nucleus, moveable within the external shell, arose from the apparent change of place which the various direction of the light produces on the central spot or inner circle of each particle. Warned, however, by the example of other observers, I shall not attempt to offer any farther conjectures concerning the nature and construction of those particles. My reader may draw what conclusion he thinks proper from the above-mentioned facts, and he may also, with little trouble, satisfy his curiosity concerning those appearances, as I find that microscopical glass globules may be had at Mr. Shutleworth's philosophical instrument shop on Ludgate Hill. I shall therefore conclude with the account of a few experiments which I have made, with a view of imitating the phenomena that are exhibited
by

by the particles of blood, the result of which seems to corroborate what has been already observed.

ON the supposition of the red particles being globular, I expected that globules of other transparent matter would exhibit the same appearances as the particles of blood, and my expectations were in great measure verified by actual experiments.

A GLASS globule was placed as an object upon the stage of the microscope, and was successively viewed through lenses of various, but not great, magnifying powers. As every part of the globule could not be at once in the focus, the whole of it was not of course equally distinct. This indistinction, however, being not very great, I shall proceed without taking any farther notice of it.

THE globule appeared like a dark circular surface, with a transparent circular spot in the middle, and in this spot there appeared

peared a distinct image of the candle or the window, or, in short, of any other object that was placed directly before it.

IN this experiment three points of difference between the glass globule and the particles of blood were remarked, *viz.* 1st, that the globule shewed a distinct, whereas the particle shewed an indistinct image of the candle; 2dly, that the inner circle of the globule is much smaller in comparison with its external boundary, than the inner circle of the particle is in comparison with its external one; and, 3dly, that the annulus or space between the two circles is uniformly dark in the glass globule, whereas in the particle it is about as clear as the internal surface, or rather clearer.

THE first and the last of these points of difference seem to depend on the imperfect transparency of the particles of blood; for in semitransparent bodies, whatever light falls upon any part of them is scattered through the whole body.

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THE second point of difference I attributed to the particles of blood being surrounded by a coagulated fluid of nearly an equal refracting power with themselves, whereas the glass globule was surrounded by air only. In order to verify this supposition, I placed the glass globule in water, and viewing it in that state through the same magnifiers that had been used before, I found that the transparent part or circle appeared much larger than in the former case *.

IN the globule of glass, as well as in the particle of blood, the inner circle may be made to appear larger or smaller, by altering

* These appearances are perfectly reconcileable to the doctrine of optics. The light, which falls from a luminous object upon the glass globule, illuminates at most one half of its surface, and in entering the surface of the glass, it is refracted towards the axis of the globule; hence the whole cone of light being contracted, must pass through a small part only of the opposite surface, and must leave the rest destitute of light. Now this contraction of the light must vary according to the difference between the refractive power of the globule and that of the surrounding medium.

the distance between the object and the microscopical lens.

IN the glass globule the inner circle may be seen to move from the middle of the dark surface, according as the candle is moved from the direct line between the object and the microscopical lens.

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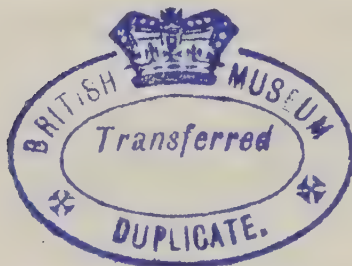
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